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SOIL POPULATION OF PLANT PARASITIC NEMATODES UNDER VARIOUS CROPPING SEQUENCES

by

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Little is known about the factors influencing the population dynamics of plant parasitic nematodes in India. Recently Chawla and Prasad (1973) and Khan *et al.* (1975, 1976) have investigated the influence of crop monocultures on the build-up of nematode populations, and noted that short term crop rotations were beneficial in reducing their numbers. Alam *et al.* (1976, 1977) studied the effect of twelve different cropping sequences, spread over for five years, on the population fluctuations of some important genera of plant parasitic nematodes and concluded that no single sequence was effective in reducing over all nematode populations. It seemed desirable to further investigate the effect of other cropping sequences on the population of plant nematodes.

Materials and methods

The experimental area was naturally infested with *Meloidogyne incognita* (Kofoid *et* White) Chitw., *Rotylenchulus reniformis* Linford *et* Oliveira, *Tylenchorhynchus brassicae* Siddiqi, *Hoplolaimus indicus* Sher, *Tylenchus filiformis* Butschli and *Trichodorus mirzai* Siddiqi. In October 1970 the area was divided into plots, 10 x 1.5 m each, and a five-year rotation sequence established as shown in Table I. There

were three replicates for each crop. The crops were barley (*Hordeum vulgare* L.) cv. BG-49, brownhemp (*Hibiscus cannabinus* L.) cv. Punjab Special, castor (*Ricinus communis* L.) cv. Local, clusterbean (*Cyamopsis tetragonaloba* Taub.) cv. Local, corn (*Zea mays* L.) cv. Ganga-5, cotton (*Gossypium* sp.) cv. Local, eggplant (*Solanum melongena* L.) cv. Pusa Purple Long, fenugreek (*Trigonella foenumgraecum* L.) cv. Local, greengram (*Phaseolus aureus* Roxb.) cv. Local, kochia (*Kochia scoparia* Schrad.) cv. Local, kulfa (*Portulaca oleracea* L.) cv. Local, marigold (*Tagetes erecta* L.) cv. Cracker Jack, mustard (*Brassica campestris* L.) cv. Laha-101, okra (*Abelmoschus esculentus* Moench.) cv. Pusa Sawani, radish (*Raphanus sativus* L.) cv. Kannoji White, turnip (*Brassica rapa* L.) cv. Redball, zinnia (*Zinnia elegans* Jacq.) cv. Brightness and fallow in different combinations. Fertilizers were applied at the equivalent of 100 lb/acre nitrogen in two equal doses, and 50 lb/acre phosphorus and potassium in one single dose. Cultivation treatments such as watering and weeding were done as necessary. Twenty soil cores to a depth of 20 cm were taken from each plot at the time of the crop harvest, and after thorough mixing nematodes were extracted from 200 g sub-samples by Oostenbrink elutriator and Baermann funnel (Southey, 1970).

Results

Corn in sequence I supported large numbers of root-knot nematode (*M. incognita*), but marigold and zinnia following corn reduced the numbers to such a low level (undetectable numbers) that even subsequently growing a susceptible crop (eggplant) did not appreciably increase the population (Table I). Okra in sequence II and brownhemp in sequence III considerably increased the numbers but growing barley following okra, and marigold following brownhemp, reduced the population to undetectable numbers. In sequence IV the numbers of root-knot nematode remained at a very low level throughout the study, probably because of the fallow period and also because non-susceptible crops were grown. Monoculture of eggplant for three consecutive seasons (April 1973 to October 1974) in sequence V resulted in a gradual build-up of the population of the nematode. Barley follow-

ing eggplant reduced the population to such an extent that even okra following barley failed to increase nematode numbers (sequence V). In all the remaining sequences the population was reduced or the initial population was maintained except in sequence IX where brownhemp favoured multiplication. Fallow following brownhemp reduced the numbers to an undetectable level.

Radish did not appear to be a good host for *R. reniformis*, and reduced the population to an undetectable level. There was some increase in nematode numbers after eggplant in cropping sequences I, II, IV, V and VI but not in VIII and XI, probably because eggplant during April-October followed fallow during October-April. Invariably multiplication of the nematode was high when eggplant was grown during October-April as compared to growing the crop during April-October. Okra, cotton and castor favoured the multiplication of the nematode but fenugreek did not.

There was drastic reduction in the population of *T. brassicae* following radish. Corn, eggplant, kochia, barley, brownhemp, kulfa and turnip considerably increased the population, whereas with marigold, zinnia, clusterbean and castor there was a decrease. Barley following kochia, okra and greengram decreased nematode numbers but barley following zinnia, eggplant and clusterbean increased them. In the former case the decrease may have been partly due to the fact that barley fails to maintain high population levels following very good hosts. Similarly, turnip following kochia did not increase the population.

The population of *H. indicus* increased when kulfa, castor, clusterbean and corn were grown but marigold, radish, kochia and fallow brought about a reduction in the numbers of the nematode. The slight increase in numbers observed in association with marigold in some of the sequences might be due to certain weeds (grasses) acting as hosts.

Radish, corn, kochia, greengram, eggplant and fenugreek markedly increased the population of *T. filiformis* in all the cropping sequences. Barley, marigold, turnip and fallow in all the cropping sequences reduced the populations to undetectable levels.

The population of *T. mirzai* remained low in all the cropping sequences. Marigold in sequence, I, II and IV, brownhemp in III and IX, okra in VI, barley in IV, corn in VII and greengram in XII increased the population to some extent.

Table I - *Effect of different cropping sequences on the population of plant parasitic nematodes.*

	S.N. Crops	Duration	Population of nematode per 200 g soil							
			Hop	Rot	Trh	Tyl	Mel	Tri	Total	Sap
I	*Initial population*		60	20	260	80	100	40	560	1600
	Radish	Oct 70-Apr 71	10	—	20	160	10	50	250	1100
	Corn	Apr 71-Oct 71	40	—	1800	240	240	20	2340	1660
	Marigold	Oct 71-Apr 72	20	—	80	20	—	—	120	1700
	Zinnia	Apr 72-Oct 72	80	—	60	20	—	—	160	1120
	Marigold	Oct 72-Apr 73	40	—	120	40	—	80	280	1240
	Marigold	Apr 73-Oct 73	140	—	40	20	—	20	220	380
	Eggplant	Oct 73-Apr 74	100	20	140	60	20	20	360	580
	Kochia	Apr 74-Oct 74	80	140	640	120	—	—	980	1280
	Barley	Oct 74-Apr 75	—	—	60	—	20	20	100	260
	Okra	Apr 75-Oct 75	120	40	80	—	40	—	280	160
II	*Initial population*		60	20	260	80	100	40	560	1600
	Radish	Oct 70-Apr 71	10	—	20	160	10	50	250	1100
	Okra	Apr 71-Oct 71	200	—	140	40	160	20	560	1180
	Marigold	Oct 71-Apr 72	40	—	40	60	—	—	140	1520
	Eggplant	Apr 72-Oct 72	120	20	100	60	120	20	440	1400
	Marigold	Oct 72-Apr 73	80	—	60	20	—	100	260	1020
	Okra	Apr 73-Oct 73	180	200	60	40	80	40	600	780
	Eggplant	Oct 73-Apr 74	60	20	120	80	120	20	420	740
	Okra	Apr 74-Oct 74	20	420	80	80	560	60	1220	1140
	Barley	Oct 74-Apr 75	40	20	300	20	20	60	460	880
	Okra	Apr 75-Oct 75	—	—	160	20	20	—	200	400
III	*Initial population*		60	20	260	80	100	40	560	1600
	Radish	Oct 70-Apr 71	10	—	20	160	10	50	250	1100
	Brownhemp	Apr 71-Oct 71	120	—	240	80	900	120	1460	1140
	Marigold	Oct 71-Apr 72	30	—	—	—	—	—	30	700
	Marigold	Apr 72-Oct 72	160	—	60	20	—	20	260	1320
	Marigold	Oct 72-Apr 73	60	—	20	80	—	60	220	620
	Cotton	Apr 73-Oct 73	180	600	100	20	—	20	920	640
	Eggplant	Oct 73-Apr 74	60	220	180	40	20	20	540	460
	Greengram	Apr 74-Oct 74	40	160	320	180	40	—	740	540
	Barley	Oct 74-Apr 75	20	—	180	—	—	—	200	700
	Okra	Apr 75-Oct 75	20	40	80	40	40	—	220	240
IV	*Initial population*		60	20	260	80	100	40	560	1600
	Radish	Oct 70-Apr 71	10	—	20	160	10	50	250	1100
	Fallow	Apr 71-Oct 71	120	—	60	—	20	80	280	860
	Marigold	Oct 71-Apr 72	40	—	40	—	—	20	100	1240
	Kulfa	Apr 72-Oct 72	160	—	280	40	—	20	500	1160
	Marigold	Oct 72-Apr 73	160	60	140	80	—	100	540	1180
	Fallow	Apr 73-Oct 73	20	20	120	40	—	20	220	540
	Eggplant	Oct 73-Apr 74	20	20	140	60	20	—	260	800
	Zinnia	Apr 74-Oct 74	80	—	40	40	—	—	160	580
	Barley	Oct 74-Apr 75	60	—	320	20	—	100	500	560
	Okra	Apr 75-Oct 75	80	—	280	160	40	—	560	200

Table I (Contd.)

S.N.	Crops	Duration	Population of nematode per 200 g soil							
			Hop	Rot	Trh	Tyl	Mel	Tri	Total	Sap
V	*Initial population*		60	20	260	80	100	40	560	1600
	Radish	Oct 70-Apr 71	10	—	20	160	10	50	250	1100
	Marigold	Apr 71-Oct 71	100	—	20	20	—	40	180	760
	Marigold	Oct 71-Apr 72	20	—	80	—	—	—	100	1560
	Fallow	Apr 72-Oct 72	280	—	120	40	—	20	460	1540
	Marigold	Oct 72-Apr 73	60	—	100	20	—	40	220	880
	Eggplant	Apr 73-Oct 73	60	40	20	80	220	40	460	460
	Eggplant	Oct 73-Apr 74	300	120	300	100	220	—	1040	4560
	Eggplant	Apr 74-Oct 74	20	20	80	160	620	40	940	480
	Barley	Oct 74-Apr 75	140	20	380	20	40	40	640	440
	Okra	Apr 75-Oct 75	120	—	40	—	80	—	240	320
VI	*Initial population*		60	20	260	80	100	40	560	1600
	Radish	Oct 70-Apr 71	10	—	20	160	10	50	250	1100
	Greengram	Apr 71-Oct 71	260	20	20	—	—	80	380	720
	Marigold	Oct 71-Apr 72	20	—	60	60	—	—	140	1000
	Castor	Apr 72-Oct 72	280	120	20	60	—	—	480	1960
	Marigold	Oct 72-Apr 73	40	40	100	60	—	40	280	1220
	Clusterbean	Apr 73-Oct 73	180	80	80	20	20	—	380	820
	Eggplant	Oct 73-Apr 74	160	180	240	60	40	—	680	820
	Clusterbean	Apr 74-Oct 74	220	—	120	40	60	—	440	680
	Barley	Oct 74-Apr 75	40	40	240	20	—	40	380	320
	Okra	Apr 75-Oct 75	80	—	40	—	—	120	240	200
VII	*Initial population*		60	20	260	80	100	40	560	1600
	Mustard	Oct 70-Apr 71	100	—	250	50	10	20	430	1700
	Corn	Apr 71-Oct 71	100	—	1360	440	80	180	2160	1340
	Fallow	Oct 71-Apr 72	30	—	50	—	—	—	80	290
	Zinnia	Apr 72-Oct 72	200	—	140	100	40	20	500	1420
	Fallow	Oct 72-Apr 73	—	—	100	40	—	60	200	1040
	Marigold	Apr 73-Oct 73	140	—	60	—	—	20	220	240
	Fenugreek	Oct 73-Apr 74	100	20	60	20	—	—	200	1760
	Kochia	Apr 74-Oct 74	20	80	400	100	—	—	600	600
	Turnip	Oct 74-Apr 75	—	—	20	—	—	—	20	240
	Okra	Apr 75-Oct 75	40	—	160	80	—	60	340	200
VIII	*Initial population*		60	20	260	80	100	40	560	1600
	Mustard	Oct 70-Apr 71	100	—	250	50	10	20	430	1700
	Okra	Apr 71-Oct 71	160	—	140	20	20	—	340	800
	Fallow	Oct 71-Apr 72	80	—	100	—	—	—	180	1080
	Eggplant	Apr 72-Oct 72	80	—	180	140	140	60	600	700
	Fallow	Oct 72-Apr 73	60	20	20	120	—	20	240	920
	Okra	Apr 73-Oct 73	220	80	80	20	—	—	400	700
	Fenugreek	Oct 73-Apr 74	100	80	100	40	80	—	400	1080
	Okra	Apr 74-Oct 74	—	80	240	60	140	—	520	920
	Turnip	Oct 74-Apr 75	80	20	280	—	—	20	400	580
	Okra	Apr 75-Oct 75	—	—	20	20	—	40	80	140

Table I (Contd.)

S.N.	Crops	Duration	Population of nematode per 200 g soil							
			Hop	Rot	Trh	Tyl	Mel	Tri	Total	Sap
IX	*Initial population*		60	20	260	80	100	40	560	1600
	Mustard	Oct 70-Apr 71	100	—	250	50	10	20	430	1700
	Brownhemp	Apr 71-Oct 71	180	—	80	120	520	160	1060	1080
	Fallow	Oct 71-Apr 72	—	—	120	20	—	—	140	1280
	Marigold	Apr 72-Oct 72	—	—	20	20	—	—	40	760
	Fallow	Oct 72-Apr 73	40	40	140	80	—	20	320	920
	Cotton	Apr 73-Oct 73	80	180	70	70	—	60	460	1880
	Fenugreek	Oct 73-Apr 74	60	20	80	40	—	20	220	680
	Greengram	Apr 74-Oct 74	20	20	140	40	20	—	240	160
	Turnip	Oct 74-Apr 75	—	20	180	—	—	—	200	500
	Okra	Apr 75-Oct 75	40	—	100	40	—	—	180	320
X	*Initial population*		60	20	260	80	100	40	560	1600
	Mustard	Oct 70-Apr 71	100	—	250	50	10	20	430	1700
	Fallow	Apr 71-Oct 71	60	—	20	20	20	20	140	400
	Fallow	Oct 71-Apr 72	50	—	60	—	—	—	110	600
	Kulfa	Apr 72-Oct 72	240	—	220	40	—	—	500	740
	Fallow	Oct 72-Apr 73	40	—	120	60	—	100	320	1300
	Fallow	Apr 73-Oct 73	60	—	100	40	—	20	220	1000
	Fenugreek	Oct 73-Apr 74	100	20	120	20	—	20	280	2900
	Zinnia	Apr 74-Oct 74	40	—	100	20	—	—	160	160
	Turnip	Oct 74-Apr 75	100	—	540	—	—	20	660	400
	Okra	Apr 75-Oct 75	—	—	160	—	—	40	200	140
XI	*Initial population*		60	20	260	80	100	40	560	1600
	Mustard	Oct 70-Apr 71	100	—	250	50	10	20	430	1700
	Marigold	Apr 71-Oct 71	160	—	80	—	—	40	280	720
	Fallow	Oct 71-Apr 72	80	—	20	—	—	20	120	1840
	Fallow	Apr 72-Oct 72	120	—	80	—	—	20	220	1100
	Fallow	Oct 72-Apr 73	—	—	60	60	—	60	180	1460
	Eggplant	Apr 73-Oct 73	160	—	100	80	100	20	460	620
	Fenugreek	Oct 73-Apr 74	160	20	160	60	20	20	440	2840
	Eggplant	Apr 74-Oct 74	20	—	280	—	100	—	400	300
	Turnip	Oct 74-Apr 75	60	—	520	20	160	60	820	360
	Okra	Apr 75-Oct 75	160	—	120	40	—	—	320	240
XII	*Initial population*		60	20	260	80	100	40	560	1600
	Mustard	Oct 70-Apr 71	100	—	250	50	10	20	430	1700
	Greengram	Apr 71-Oct 71	340	—	20	20	—	100	480	240
	Fallow	Oct 71-Apr 72	—	—	160	—	—	—	160	290
	Castor	Apr 72-Oct 72	280	100	80	20	—	—	480	1180
	Fallow	Oct 72-Apr 73	20	60	60	40	—	—	180	500
	Clusterbean	Apr 73-Oct 73	480	20	20	140	80	20	760	740
	Fenugreek	Oct 73-Apr 74	100	20	140	120	20	—	400	800
	Clusterbean	Apr 74-Oct 74	240	—	80	60	—	—	380	460
	Turnip	Oct 74-Apr 75	—	20	440	40	20	20	540	640
	Okra	Apr 75-Oct 75	120	—	140	—	—	—	260	160

Hop = *Hoplolaimus indicus*, Rot = *Rotylenchulus reniformis*, Trh = *Tylenchorhynchus brassicae*, Tyl = *Tylenchus filiformis*, Mel = *Meloidogyne incognita* larvae, Tri = *Trichodorus mirzai*, Total = Total parasitic, Sap = Total saprozoic.

Discussion and conclusion

The results reported here confirm earlier findings that none of the cropping sequences had an equal effect in reducing the population densities of the diverse species of plant parasitic nematodes. By and large sequence X (mustard-fallow-fallow-kulfa-fallow-fallow-fenugreek-zinnia-turnip-okra) was the most effective in reducing the numbers of the four important plant parasitic nematodes viz., *M. incognita, R. reniformis, T. brassicae* and *T. filiformis*. These rotations can be shortened by growing resistant varieties and this possibility is being studied. Marigold and zinnia were found to be highly effective in reducing the population of almost all the parasitic nematodes tested, while eggplant favoured multiplication of all the nematodes. These results confirm earlier findings (Khan *et al.*, 1976; Alam *et al.*, 1976, 1977, 1980). Some of the observed increases in nematode numbers in fallow may have been due to the presence of weeds which supported their multiplication.

High densities of *M. incognita* in association with okra, brown-hemp and eggplant were not surprising because all these crops have been found susceptible to the root-knot nematode. Low numbers on marigold, barley, castor, radish and turnip were expected since these plants have been reported as poor hosts. Good (1973) also reported that small grain crops like barley are helpful in reducing the population densities of root-knot nematodes. He also reported that the root-knot nematode increased on cotton (Good 1972) but this was not observed in the present study, possibly because marigold or fallow preceding cotton reduced the populations to a very low level that any multiplication on cotton was undetectable.

Mustard did not favour reproduction of *R. reniformis* and these results are in agreement with those of Khan and Khan (1973).

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SUMMARY

Different cropping sequences influenced the populations of several species of plant parasitic nematodes, but to a varying degree. Marigold and zinnia suppressed the populations of almost all the test species of nematodes, while eggplant favoured their multiplication. Cotton following marigold or fallow did not support *Meloidogyne incognita*.

RIASSUNTO

Popolazioni nel terreno di nematodi fitoparassiti in differenti rotazioni.

Differenti rotazioni hanno influenzato in maniera diversa le popolazioni nel terreno di vari nematodi fitoparassiti. La violetta africana e la zinnia hanno pressocché eradicato le popolazioni di quasi tutti i nematodi presenti nel terreno, mentre la melanzana ne ha favorito l'aumento. Il cotone, seguito da violetta o da maggese nudo ha depresso le popolazioni di *Meloidogyne incognita.*

LITERATURE CITED

ALAM M. M., KHAN A. M. and SAXENA S. K., 1976 - Control of plant parasitic nematodes by management practices: crop rotation. *Proc. Nat. Acad. Sci. India, 46B*: 308-312.

ALAM M. M., SAXENA S. K. and KHAN A. M., 1977 - Influence of different cropping sequences on soil population of plant parasitic nematodes. *Nematol. medit., 5*: 65-72.

ALAM M. M., SIDDIQI Z. A., KHAN A. M. and SAXENA S. K., 1980 - Effect of different cropping sequences on the population of plant parasitic nematodes. *Indian J. Nematol., 10*: 35-39.

CHAWLA M. L. and PRASAD S. K., 1973 - Multiple cropping and nematodes. I. Effect of fertility management and intensive rotations on nematode populations and crop yield. *Indian J. Nematol., 3*: 34-49.

GOOD J. M., 1972 - Management of plant parasitic nematode populations. *Proc. Ann. Tall Timbers Conf. Eco. Control by Habitat Management*, Tallahassa, Fla.: 109-127

GOOD J. M., 1973 - « Nematodes ». In *Soybeans: improvement, production and uses* (Ed. - B. E. Caldwell), Am. Soc. Agron.: 527-543.

KHAN A. M., SAXENA S. K., SIDDIQI Z. A. and UPADHYAY R. S., 1975 - Control of nematodes by crop rotation. *Indian J. Nematol., 5*: 214-221.

KHAN A.M., SIDDIQI Z. A., ALAM M. M. and SAXENA S. K., 1976 - Note on the effect of different cropping sequences on the population of plant parasitic nematodes. *Indian J. Agric. Sci., 46*: 439-441.

KHAN F. A. and KHAN A. M., 1973 - Studies on the reniform nematode, *Rotylenchulus reniformis.* I. Host range and population changes. *Indian J. Nematol., 3*: 24-30.

SOUTHEY J. F., 1970 - *Laboratory methods for work with plant and soil nematodes.* Tech. Bull. No. 2, Min. Agr. Fish. Food, H.M.S.O., London.

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