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# INFLUENCE OF DIFFERENT CROPPING SEQUENCES ON SOIL POPULATIONS OF PLANT PARASITIC NEMATODES

by

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Crop rotation measures for controlling phytoparasitic nematodes aim to keep the population density of a certain species at low levels incapable of inflicting damage. This is achieved by growing non-susceptible crops in between the periods of growing susceptible crops. Thus, there is always a need to search for plants that could be used in rotation programmes and that are acceptable to growers. Chawla and Prasad (1973) and Khan *et al.* (1973) have shown that monoculture of some crops resulted in the build up of nematode populations, but proper crop rotation practices reduced the populations to safe levels. In all these studies the crop rotation trials were based on a 3-year rotation programme. Moreover, the crops included were mostly vegetables. In the present study the objective was to determine the effect of different cropping sequences, incorporating some non-vegetable crops spread over 5 years, on densities of plant nematode species naturally occurring in the Aligarh soils.

## *Materials and methods*

Experimental plots, naturally infested with *Hoplolaimus indicus* Sher, *Rotylenchulus reniformis* Linford *et* Oliveira, *Tylenchorhynchus bassicae* Siddiqi, *Tylenchus filiformis* Butschli, *Meloidogyne incognita* (Kofoid *et* White) Chitwood and *Trichodorus mirzai* Siddiqi, were established in October 1970. The various cropping systems included

bengal gram (*Cicer arietinum* L.) cv. RS-6, broadbean (*Vicia faba* L.) cv. Local, brownhemp (*Hibiscus cannabinus* L.) cv. Punjab Special, clusterbean (*Cyamopsis tetragonaloba* Taub.) cv. Big-podded, castor (*Ricinus communis* L.) cv. Local, corn (*Zea mays* L.) cv. Ganga-5, cotton (*Gossypium* sp. L.) cv. Local, eggplant (*Solanum melongena* L.) cv. Pusa Purple Long, green gram (*Phaseolus aureus* Roxb.) cv. Local, kochia (*Kochia scoparia* Schrad.) cv. Local, kulfa (*Portulaca oleracea* L.) cv. Local, marigold (*Tagetes erecta* L.) cv. Cracker Jack, okra (*Abelmoschus esculentus* Moench.) cv. Pusa Sawani, tomato (*Lycopersicon esculentum* Mill.) cv. Marglobe and zinnia (*Zinnia elegans* Jacq.) cv. Brightness in different rotation patterns, up to October 1975 (Table I). Each experimental plot measured 10 x 1.5 metre. Fertilizers at the rate of 100 lbs of N per acre were given in two equal doses, and 50 lbs each of P and K per acre in one single dose. Soil samples (20 cores - 2.0 x 20 cm) for nematode assays were collected and mixed thoroughly and a 200 g soil sub-sample was processed using Oostenbrink's elutriator and Baermann funnels (Southey, 1970).

## *Results*

Results presented in table I show that the populations of *M. incognita* were increased in all the fields during the period October '70 to April '71 with tomato as the first (base) crop in all the cropping sequences. Corn, green gram, marigold and fallow considerably decreased the numbers of larvae. Growing tomato or eggplant following any of these crops did not greatly increase root-knot populations and broadbean and kochia suppressed populations. The numbers of larvae of root-knot were greatly increased when okra and brownhemp followed tomato. Of all the crops used in six different cropping sequences, brownhemp proved to be a very 'good host' for *M. incognita* as the multiplication rate was very high (R = 6).

The population of *R. reniformis* was low at the start of the experiment (20 nematodes/200 g soil). Growing tomato-corn-tomato in sequence I; tomato-okra-zinnia-tomato in sequence II; tomato-brownhemp-tomato in sequence III; tomato-fallow-tomato, in sequence IV; tomato-marigold-tomato-fallow in sequence V did not increase numbers up to October '72. Thereafter, the populations increased to some extent in all the sequences where tomato, eggplant, marigold, green gram, castor, cotton and bengal gram were grown.

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

| S.N. | Crops | Duration | Population of nematodes per 200 g soil | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Hop | Rot | Trh | Tyl | Mel | Tri | Total | Sap |
| I | *Initial population* | | 60 | 20 | 260 | 80 | 100 | 40 | 560 | 1600 |
| | Tomato | Oct '70-Apr '71 | 10 | — | 40 | 20 | 180 | 20 | 270 | 920 |
| | Corn | Apr '71-Oct '71 | 20 | — | 940 | 100 | 100 | 60 | 1220 | 880 |
| | Tomato | Oct '71-Apr '72 | 30 | — | 30 | — | — | — | 60 | 5800 |
| | Zinnia | Apr '72-Oct '72 | 540 | 20 | 220 | 100 | 40 | 100 | 1020 | 1600 |
| | Tomato | Oct '72-Apr '73 | 120 | 100 | 60 | 60 | 100 | 60 | 500 | 1320 |
| | Marigold | Apr '73-Oct '73 | 60 | 80 | 80 | 20 | 20 | 20 | 280 | 800 |
| | Broadbean | Oct '73-Apr '74 | 20 | 100 | 120 | 160 | — | 20 | 420 | 2600 |
| | Kochia | Apr '74-Oct '74 | 120 | — | 100 | 20 | — | — | 240 | 680 |
| | Bengal gram | Oct '74-Apr '75 | 40 | 40 | 500 | 20 | 60 | — | 660 | 500 |
| | Okra | Apr '75-Oct '75 | 120 | — | 160 | — | — | — | 280 | 400 |
| II | *Initial population* | | 60 | 20 | 260 | 80 | 100 | 40 | 560 | 1600 |
| | Tomato | Oct '70-Apr '71 | 10 | — | 40 | 20 | 180 | 20 | 270 | 920 |
| | Okra | Apr '71-Oct '71 | 40 | — | 160 | 80 | 200 | 80 | 560 | 940 |
| | Tomato | Oct '71-Apr '72 | — | — | 240 | 40 | 260 | — | 540 | 1960 |
| | Eggplant | Apr '72-Oct '72 | 300 | 120 | 260 | 100 | 520 | 60 | 1360 | 1940 |
| | Tomato | Oct '72-Apr '73 | 140 | 20 | 180 | 160 | 520 | 120 | 1140 | 1760 |
| | Okra | Apr '73-Oct '73 | 240 | 320 | 220 | 100 | 680 | 20 | 1580 | 740 |
| | Broadbean | Oct '73-Apr '74 | 40 | 140 | 260 | 60 | 20 | — | 520 | 1100 |
| | Okra | Apr '74-Oct '74 | 20 | 40 | 100 | 100 | — | — | 260 | 560 |
| | Bengal gram | Oct '74-Apr '75 | 80 | — | 720 | — | — | 40 | 840 | 520 |
| | Okra | Apr '75-Oct '75 | 80 | — | 40 | — | 40 | 80 | 240 | 400 |
| III | *Initial population* | | 60 | 20 | 260 | 80 | 100 | 40 | 560 | 1600 |
| | Tomato | Oct '70-Apr '71 | 10 | — | 40 | 20 | 180 | 20 | 270 | 920 |
| | Brownhemp | Apr '71-Oct '71 | 40 | — | 120 | 60 | 1080 | 40 | 1340 | 1260 |
| | Tomato | Oct '71-Apr '72 | 20 | — | 120 | — | 100 | 20 | 260 | 1680 |
| | Marigold | Apr '72-Oct '72 | 40 | 200 | 60 | — | 60 | 20 | 380 | 1340 |
| | Tomato | Oct '72-Apr '73 | — | 40 | 160 | 80 | 80 | 20 | 380 | 1500 |
| | Cotton | Apr '73-Oct '73 | 160 | 260 | 280 | 180 | 120 | 60 | 1060 | 760 |
| | Broadbean | Oct '73-Apr '74 | 80 | 180 | 80 | 100 | — | — | 440 | 400 |
| | Green gram | Apr '74-Oct '74 | 40 | 220 | 160 | 120 | — | 20 | 560 | 760 |
| | Bengal gram | Oct '74-Apr '75 | — | 100 | 340 | 20 | 40 | — | 500 | 640 |
| | Okra | Apr '75-Oct '75 | 80 | — | 80 | — | — | — | 160 | 240 |

*(Contd. table I)*

| S.N. | Crops | Duration | Population of nematodes per 200 g soil | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Hop | Rot | Trh | Tyl | Mel | Tri | Total | Sap |
| IV | *Initial population* | | 60 | 20 | 260 | 80 | 100 | 40 | 560 | 1600 |
| | Tomato | Oct '70-Apr '71 | 10 | — | 40 | 20 | 180 | 20 | 270 | 920 |
| | Fallow | Apr '71-Oct '71 | 80 | — | 80 | 20 | 20 | 20 | 220 | 820 |
| | Tomato | Oct '71-Apr '72 | 140 | — | 40 | 40 | 80 | — | 300 | 1560 |
| | Kulfa | Apr '72-Oct '72 | 360 | 20 | 680 | 100 | 60 | 260 | 1480 | 1040 |
| | Tomato | Oct '72-Apr '73 | 20 | 20 | 160 | — | 60 | 60 | 320 | 1600 |
| | Fallow | Apr '73-Oct '73 | 180 | — | — | 20 | — | — | 200 | 580 |
| | Broadbean | Oct '73-Apr '74 | 80 | — | 60 | — | — | 20 | 160 | 280 |
| | Zinnia | Apr '74-Oct '74 | 20 | 60 | 120 | — | — | — | 200 | 400 |
| | Bengal gram | Oct '74-Apr '75 | 40 | — | 260 | 60 | 40 | 80 | 480 | 560 |
| | Okra | Apr '75-Oct '75 | 280 | — | 80 | 40 | — | — | 400 | 320 |
| V | *Initial population* | | 60 | 20 | 260 | 80 | 100 | 40 | 560 | 1600 |
| | Tomato | Oct '70-Apr '71 | 10 | — | 40 | 20 | 180 | 20 | 270 | 920 |
| | Marigold | Apr '71-Oct '71 | 80 | — | 80 | — | 20 | 80 | 260 | 1460 |
| | Tomato | Oct '71-Apr '72 | — | — | 80 | 20 | 40 | 20 | 160 | 1520 |
| | Fallow | Apr '72-Oct '72 | 220 | — | 160 | 20 | 20 | 60 | 480 | 840 |
| | Tomato | Oct '72-Apr '73 | 140 | 60 | 140 | 100 | 100 | 40 | 580 | 1060 |
| | Eggplant | Apr '73-Oct '73 | 260 | 80 | 200 | 140 | 860 | 20 | 1560 | 840 |
| | Broadbean | Oct '73-Apr '74 | 40 | 20 | 60 | 20 | — | — | 140 | 1180 |
| | Eggplant | Apr '74-Oct '74 | 140 | 80 | 400 | 140 | 240 | — | 1000 | 1220 |
| | Bengal gram | Oct '74-Apr '75 | 40 | — | 640 | 60 | 40 | 40 | 820 | 420 |
| | Okra | Apr '75-Oct '75 | 40 | — | 80 | — | — | — | 120 | 120 |
| VI | *Initial population* | | 60 | 20 | 260 | 80 | 100 | 40 | 560 | 1600 |
| | Tomato | Oct '70-Apr '71 | 10 | — | 40 | 20 | 180 | 20 | 270 | 920 |
| | Green gram | Apr '71-Oct '71 | 60 | 160 | 140 | — | 20 | 20 | 400 | 1100 |
| | Tomato | Oct '71-Apr '72 | 20 | — | 40 | 60 | — | — | 120 | 960 |
| | Castor | Apr '72 -Oct '72 | 300 | 140 | 100 | 40 | 80 | 20 | 680 | 860 |
| | Tomato | Oct '72-Apr '73 | 160 | 60 | 160 | 60 | 160 | 100 | 700 | 1360 |
| | Clusterbean | Apr '73-Oct '73 | 160 | 60 | 40 | 160 | 180 | 20 | 620 | 920 |
| | Broadbean | Oct '73-Apr '74 | 420 | 60 | 120 | 60 | — | 20 | 680 | 1100 |
| | Clusterbean | Apr '74-Oct '74 | 80 | — | 60 | 80 | 20 | — | 240 | 920 |
| | Bengal gram | Oct '74-Apr '75 | 60 | 60 | 440 | 220 | — | 20 | 800 | 1760 |
| | Okra | Apr '75-Oct '75 | 80 | — | 400 | 20 | — | — | 500 | 360 |

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.

Table II - *Host suitability to certain nematodes based on crop rotation trials.*

| Crops | Host suitability to nematodes | | | | | |
|---|---|---|---|---|---|---|
| | Hop | Rot | Trh | Tyl | Mel | Tri |
| Bengal gram | P | G | G | P | G | P |
| Broadbean | P | P | G | P | P | P |
| Brownhemp | G | P | G | G | G | P |
| Clusterbean | P | P | P | G | G | P |
| Castor | G | G | P | P | G | P |
| Corn | G | P | G | G | P | P |
| Cotton | G | G | G | G | G | P |
| Eggplant | G | G | G | G | G | P |
| Green gram | P | G | G | G | P | P |
| Kochia | G | P | P | P | P | P |
| Kulfa | G | P | G | G | G | G |
| Marigold | P | G | P | P | P | P |
| Okra | G | P | G | G | G | P |
| Tomato | P | G | G | P | G | G |
| Zinnia | G | P | G | G | P | G |

G = good host, P = poor host, Hop = *Hoplolaimus indicus*, Rot = *Rotylenchulus reniformis*, Trh = *Tylenchorhynchus brassicae*, Tyl = *Tylenchus filiformis*, Mel = *Meloidogyne incognita*, Tri = *Trichodorus mirzai*.

In sequence VI, however, green gram increased populations considerably in October '71. Generally marigold and cotton proved to be very good hosts with multiplication rates of the nematode of 10 and 6 respectively.

*T. brassicae* was more abundant on corn, zinnia, broadbean, bengal gram, okra, tomato, eggplant, brownhemp, cotton, green gram and kulfa than on marigold and clusterbean. Numbers of *T. brassicae* increased considerably on kulfa (R = 17) and bengal gram (R = 2-7). Tomato and okra favoured multiplication, but when grown following a highly susceptible crop, decreased numbers of *T. brassicae*. At the end of the experiment there was a decline in the popu-

lations as compared to the initial population in all the cropping sequences except in sequence VI.

No cropping sequence was found effective in reducing the population of *H. indicus*. Generally tomato, broadbean, clusterbean and marigold suppressed the population of nematodes. Populations decreased under bengal gram but increased when it was grown following okra. Zinnia, kochia, okra, eggplant, cotton and kulfa brought about considerable increases in the populations of *H. indicus*. Populations also increased under fallow but this was probably due to the presence of graminaceous weeds which were hosts for the nematode.

Populations of *T. filiformis* and *T. mirzai* at the end of the studies were below the detectable level in all the cropping sequences. Corn, zinnia, okra, eggplant, cotton, brownhemp, green gram, kulfa and clusterbean favoured the multiplication of *T. filiformis* but tomato, marigold, broadbean and fallow suppressed populations. Bengal gram following kochia, green gram and zinnia increased populations but following broadbean, okra, eggplant and clusterbean nematode numbers decreased. *T. mirzai* was abundant around zinnia and tomato following eggplant; kulfa following tomato; and tomato following castor. All the other crops suppressed the population of *T. mirzai*.

## *Discussion and conclusion*

The results showed that all the cropping sequences tested decreased the populations of *R. reniformis*, *M. incognita*, *T. filiformis* and *T. mirzai* to almost undetectable levels by the end of the experiment. The population of *T. brassicae* was also reduced considerably in all the sequences except in sequence VI where the numbers increased. None of the cropping sequences reduced the population of *H. indicus*.

These studies confirm the earlier findings (Oostenbrink *et al.*, 1957; Daulton and Curtis, 1963; Winoto-Suatmadji, 1969; Khan *et al.*, 1971; Cohn and Mordechai, 1974) that marigold is still the best crop to suppress the population of most of the phytonematodes. In these studies broadbean and kochia were also found to be very effective in reducing the population of almost all the nematodes studied here. Tomato and okra have been found to favour multiplication of *T. brassicae* (Siddiqi *et al.*, 1972) but these crops when grown following

a highly susceptible crop, bring about reduction in population. This is because a highly susceptible crop with a high ' ceiling level ' leads to a considerable increase in nematode numbers and when such a crop is followed by a less susceptible crop with a low ' ceiling level ', the population is not maintained and nematode numbers fall. This is in agreement with findings of Jones (1956) and Seinhorst (1967). Broadbean and kochia have been found for the first time to be poor hosts for most of the nematodes studied here (Table II). Furthermore, these results confirm and extend previously reported results (Good, 1968; Khan *et al.*, 1973, 1976; Nusbaum and Ferris, 1973; Chawla and Prasad, 1973).

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SUMMARY

The population densities of plant parasitic nematodes were influenced by different cropping sequences. All the cropping sequences tested brought about reductions in the populations of *Rotylenchulus reniformis, Meloidogyne incognita, Tylenchus filiformis* and *Trichodorus mirzai* to almost undetectable levels by the end of the experiment. This was also the case with *Tylenchorhynchus brassicae* except in one cropping sequence. None of the sequences reduced the population of *Hoplolaimus indicus*. Broadbean and kochia, in addition to marigold, were found to suppress the population of most of the phytonematodes. Brownhemp, on the other hand, was found to be most susceptible to *M. incognita.*

RIASSUNTO

*Influenza degli avvicendamenti di colture sulle popolazioni di nematodi fitoparassiti nel terreno.*

I livelli di popolazione di nematodi fitoparassiti nel terreno sono stati influenzati da diverse sequenze di colture. Tutte le colture avvicendate hanno ridotto le popolazioni di *Rotylenchulus reniformis, Meloidogyne incognita, Tylenchus filiformis* e *Trichodorus mirzai* a livelli non determinabili, alla fine dell'esperimento. Lo stesso effetto è stato ottenuto per *Tylenchorhynchus brassicae,* eccetto per un tipo di avvicendamento, mentre nessuna sequenza ha ridotto le densità di *Hoplolaimus inaicus.*

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