INTRODUCTION AND REVIEW OF LITERATURE
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Plant parasitic nematodes constituting a substantial portion of soil biota are cosmopolitan and attack a large number of crops; and they are now firmly recognized as potentially serious constraints to crop productivity. They present some of the most difficult pest problems encountered in the agricultural economy by way of incurring enormous losses to crops.

Although accurate information on the extent of crop losses caused by plant parasitic nematodes is difficult to assess but approximate losses have been expressed by many workers. For instance, Stapel (1953) estimated an average annual loss of 50,000,000 kroner ($2.1 million) resulting from the attack of the cereal root eelworm, Heterodera avenae in Denmark. Southey and Samuel (1954) found an average annual loss in potato to the tune of £2 million resulting from Heterodera rostochiensis in U.K. and Wales in 1949. Orr (1984), in Western Texas, estimated an annual loss of 85,600 bales in cotton yield due to Meloidogyne incognita. Some other estimates of annual losses caused by nematodes ranged from 250 million dollars (Hutchinson et al., 1961) to 500 million dollars (Cairns, 1955). The yearly losses estimated by the United States Department of Agriculture (U.S.D.A.) in 16 crops amount to $372,335,000 (Taylor, 1967). Good (1968) reported that out of 10% loss of soybean crops due
to nematodes the contribution of root-knot and soybean cyst nematodes was 4.40% and 2.00% respectively. Feldmesser et al. (1971) while working on 16 field crops, 23 fruit, nut and vegetable crops and all ornamental crops in U.S.A., estimated an average annual loss of $1,590,326,934 due to nematodes. Loss in marketable yields at highest preplant density in some vegetables were recorded by several workers (Olthof and Potter, 1972, 1973; Olthof et al., 1973, 1974; Potter and Olthof, 1974). Yield losses of 20-59% have been reported for cowpea (Ogunfowora, 1976). Ogunfowora (1976) also reported losses ranging from 10 to 89% depending on the tomato cultivar and level of root-knot infestation in the field soil. In upland rice, loss is put at 75% in the Ivory coast (Diamonde, 1981). Sasser (1979, 1980) reported that 6 Meloidogyne spp. are responsible for about 95% of the damage to crops.

In our country, it is not fully known as to how much losses nematodes cause to crops by way of damage. However, Krishnappa (1985) has summarized the crop losses in terms of money or percentage of area infected due to the plant parasitic nematodes. Van Berkum and Seshadri (1970) reported the loss of $10 million from 'ear cockle' disease caused by Anguina tritici in wheat and $8 million due to 'molya disease' caused by Heterodera avenae in the province of Rajasthan. Besides this, crop loss in coffee caused by Pratylenchus coffeae worth $3 million was also assessed. Paruthi and Bhatti (1985) reported a loss of
2.85% in yield of wheat due to *Anguina tritici*. In another report Handa *et al.* (1985) estimated the losses in barley due to *H. avenae* to the tune of Rs. 1687 - 5911 per hectare. Sen (1958) reported a loss of 70% in chillies, eggplant, tomato and okra. Bhatti and Jain (1977) and Jain and Bhatti (1978) estimated that losses due to *Meloidogyne incognita* in okra, tomato and eggplant were 91, 46 and 47% respectively. Reddy (1985a) reported that the crop loss of tomato due to *M. incognita* was 39.70%. In case of peas *M. incognita* caused 19.95 - 20.42% losses in the yield (Reddy, 1985b).

The losses incurred by nematode pests, in terms of reduced crop yields and lowered quality of products, are of such magnitude that they require the best use of control measures. The methods of nematode control are not much different from those employed against other parasitic agencies. They traditionally fall in four broad categories, viz., physical, chemical, biological and cultural methods.

The effects of physical factors such as steam sterilization of soil, hot water treatment etc. have been reviewed by Jenkins (1960), Southey (1965) and Cuany (1971). The role of major environmental factors, particularly those concerning the soil environment, on the growth and decline of nematode population has been reviewed by Oostenbrink (1960), Wallace (1965), Seinhorst (1970), Ritter (1976), Norton (1978, 1979), Van Gundy (1978), Ferris and Van Gundy (1979) and Taylor and Nelson (1981).
Among the chemical factors nematicides have been widely used to manage the population of plant parasitic nematodes. The literature has been nicely reviewed by Peachy (1965), Smart (1969), Van Gundy and McKenry (1977), Van Berkum and Hoestra (1979), Lamberti (1979) and Wright (1981).

Biological method includes the effect of predacious or parasitic micro-organisms such as nematodes, fungi and bacteria, etc. (Sayre, 1971, 1980a, b; Norton, 1978; Mankau, 1980).


The main goal of the present study is to manage and control the plant parasitic nematodes to help ameliorate crop production. Emphasis is on evolving cheaper and easily accessible control measures. For this, the effect of organic soil amendments both conventional as well as non-conventional, has been studied on the population of plant parasitic nematodes which commonly
inhabit the Aligarh soils. A review on this aspect is given below.

**Organic amendments:**

Effect of different kinds of organic matters on plant parasitic nematodes has been investigated by many scientists. The organic additives used were mostly of plant origin or waste farm products. In most of the cases these were found to have suppressive effects on nematode disease development, however, their impact on improving plant growth and crop yield was not consistent. The early literature on nematode control stressed the importance of keeping the organic contents of soil high. An overview of the work done on the subject is as follows.

Linford *et al.* (1938) observed a significant reduction in root-knot nematode population when chopped pine apple leaves were applied to the soil at the rate of 50-200 tons/acre. This work of Linford and co-workers sparked an interest in various organic materials as possible soil amendments for the control of plant nematode diseases. Thus, largely for practical reasons, phytonematologists became interested in organic soil amendments.

Duddington and Duthoit (1960) noted high reduction in the population of *Heterodera avenae* when chopped cabbage leaves were incorporated into the infested plots, while *Hoplolaimus tylenchiformis* and *Pratylenchus penetrans* populations were managed by allowing pumpkin pieces to rot in the field
Chopped leaves of many plants significantly reduced the root-knot nematode (Hameed, 1970; Mankau, 1962, 1968; Haseeb et al., 1978, 1984b). Green leaves of many plants viz., *Azadirachta indica*, *Melia azedarach*, *Cassia fistula*, *C. occidentalis*, *Crotalaria juncea* and *Sesbania aculeata* significantly reduced the population and root-knot development of *Meloidogyne javanica* (Singh, 1965; Singh and Sitaramaiah, 1967, 1973; Zaiyd, 1977; Gupta and Ram 1981; Ram and Gupta, 1980, 1982). Gradual reduction in the population of *Meloidogyne hapla* was observed by adding various parts of *Crotalaria* sp. and marigold (Yuhara, 1971a, b); of *Tylenchorhynchus dubius* and *Hoplolaimus* sp. by the addition of homogenized leaves of corn, tomatoes and hemlock (Miller, 1978; Miller et al. 1973b). Neem leaves (Zaiyd, 1977) resulted in satisfactory control of root-knot nematodes. In a similar study Haseeb and Alam (1984) noted that chopped floral plant parts reduced the soil population of many nematodes.

Mian and Rodriguez-kabana (1982b, c) pointed out that spent coffee grinds, *Crotalaria*, Kudzu or ramie hays applied at 1/2 (W/W) were most effective in reducing root-knot galling caused by *Meloidogyne arenaria* on *Cucurbita pepo*. *Longidorus elongatus* were reduced by incorporating raspberry canes to the soil (Taylor and Murant, 1966).

*Tagetes erecta*, *I. pumila* and *Calendula officinalis* were found effective as green crop manure to control stem nematode
infection on strawberry when applied nine months before planting (Andreeva, 1975). In another report, the nematode population was found significantly reduced by adding green manure to the soil (Gour and Prasad, 1970; Sitaramaiah, 1978).

It has been advocated that the amendments may have toxic principles as has been shown by nematicidal properties of water extracts of *Anagallis arvensis* (Nene and Thapaliyal, 1966), *Erigeron linifolius* (Nene and Kumar, 1967), *Helenium* hybrid (Gommers, 1971), ginger, garlic and pepper (Sukul *et al.*, 1974), *Urtica urens* and *Cephaloria syriaca* (Mohammad *et al.*, 1981), *Argemone maxicana* and garlic (Nath *et al.*, 1982a, b), *Digitaria decumbans* (Haroon and Smart Jr., 1983) *Tagetes patula* (Rajvanshi *et al.*, 1985). Recently Tiyagi *et al.* (1985) have reported nematicidal nature of water extracts of different plant parts of some members of the family compositae.

(1976) pointed out that neem leaf extract significantly reduced the root populations of Pratylenchus brachyurus under semifield conditions.

Latices of some plants were highly toxic to plant parasitic nematodes, though to varying extent. The toxicity increased with an increase in the concentration of the latices and exposure period. Hatching of the root-knot larvae was also reduced by plant latices (Haseeb et al., 1984; Zurreen and Khan, 1984).

Van der Laan (1956) reported that Heterodera rostochiensis population was reduced by farm yard manure and compost in potato. Inhibition in the population of plant parasitic nematodes with farmyard manures and better yield of crops was reported by Duddington et al. (1961), Patel and Desai (1964), Hams and Wilkin (1964), Nollen (1964), Vlk (1972, 1973) and Resck et al. (1982). Reduction in gall index on tomato caused by Meloidogyne incognita was reported as the quantity of compost increased (Guiran and Bonnel, 1979). Roy (1976, 1979) observed that the root-knot on jute and rice caused by Meloidogyne incognita was reduced by amending the soil with decaffeinated tea waste and water hyacinth compost. Contradictory reports indicating failure of composted materials to control root-knot and other nematodes have also been published (Wager, 1945; Alam, 1976).
Heald and Burton (1968), Saka (1978) and Hornick et al. (1984) pointed out that organic nitrogen in the form of activated sewage sludge was more effective than ammonium nitrate for reducing the population of *Belonolaimus longicaudatus* and *Hypsoeperine graminis* in turf grass.

Paddy husk was found highly effective to reduce the infection of *Meloidogyne javanica* on various crop plants (Choudhary, 1981). Johnson (1959, 1962, 1963, 1971, 1972, 1974), and Johnson et al. (1967) used large number of dried residues such as oat straw, alfalfa, orchard grass, fescue and flax residues to reduce root-knot on tomato. Wheat straw (Gour and Prasad, 1970) and rice husk (Sikora et al., 1973) also reduced the root-knot nematode population to varying degree. Tomerlin and Smart (1969) found that the populations of *Belonolaimus longicaudatus* and other plant parasitic nematodes were reduced by the application of rice straw at the rate of 9.0 or 17.9 t/ha. Cereal straw, oat straw, buck wheat hull, cocoabean hull and timothy hay were found capable of reducing the population of *Pratylenchus penetrans* (Walker and Specht, 1967). Mankau (1962) and Mankau and Minter (1962) used oat-hay, alfalfa hay, alfalfa pallets, cotton waste and sugarbeet pulp to reduce the population of *Tylenchulus semipenetrans*. Mortality of *Meloidogyne incognita* and *Pratylenchus penetrans* was caused by extracts of rye and timothy plant residues decomposing in soil under laboratory and field condition (Sayre et al., 1965); and
of *Tylenchorhynchus dubius* and *Hoplolaimus* spp. by leaves and stem extracts of bean and leaves extracts of tobacco (Miller *et al.*, 1973b). Hatching of eggs of *Meloidogyne incognita* was inhibited by addition of various plant materials of alfalfa and soybean to soil (Johnson and Shamiyeh, 1975).

Sitaramaiah (1978) noted that dry straw and wood sawdust can control the plant parasitic nematodes to varying degree. Singh *et al.* (1967) and Singh and Sitaramaiah (1967, 1971a, b) while applying sawdust in okra and tomato and Srivastava *et al.* (1971) in tomato and eggplant observed significant reduction in the intensity of root-knot on these crops. Ponchillia (1972) has pointed out that *Xiphinema americanum* was able to survive at high organic matter contents.


Alam *et al.* (1977b) found that the population build up of *Hoplolaimus indicus*, *Helicotylenchus indicus*, *Rotylenchulus reniformis*, *Tylenchorhynchus brassicace*, *Tylenchus filiformis* and *Meloidogyne incognita* was effectively suppressed by the
application of bone meal in 12 different crops.

Miller (1979) and Prasad et al. (1984) claimed that some vegetable oils of corn, cotton, mustard, linseed, olive, safflower and sunflower generally reduced the population of Pratylenchus penetrans and Meloidogyne graminicola.

Oil-seed cakes/meals probably got greatest favour of a large number of workers particularly from India. It is partly due to their effectiveness in most of the cases, their availability in bulk and the ease with which they could be applied.

Lear (1959) obtained significant reduction of Globodera rostochiensis, Heterodera schachtii and Meloidogyne javanica; Miller and Taylor (1970) of Globodera tabacum; Mankau (1963) and Mankau and Minteer (1962) of Tylenchulus semipenetrans and Meloidogyne spp. by adding castor pomace.

Reduction in root-knot injury in tomato, eggplant, okra and chilli was observed after incorporating the oil-cakes to the infested soil (Singh, 1965; Singh and Sitaramaiiah, 1966, 1971a, 1973; Goswami and Swarup, 1971; Srivastava et al., 1971; Gowda and Shetty, 1973 and Alam et al., 1980). Singh and Sitaramaiiah (1966) observed that the root-knot on tomatoes, grown after the okra crop, can be checked by the residual effect of oil-cakes in the same field without further amendment.

Suppression of root-knot in soil amended with tung nut meal was observed by Gill (1952); and that of Pratylenchus
pentrans with corn meal and soybean meal by Walker (1969), Walker et al. (1967) and Walker and Specht (1967).

Oil-cakes also showed significant reduction in the population of nematodes attacking *moong* (Mishra and Prasad, 1974), wheat (Gour and Prasad, 1970; Mishra and Prasad, 1974), wheat followed by *moong* and maize (Prasad et al., 1972) and paddy (Mathur and Prasad, 1973).

Ismail et al. (1976) reported that all the oil-cakes tested were equally effective on different varieties of tomato against a number of plant parasitic nematodes. Alam et al. (1977c) noted that oil-cakes of castor, mustard, neem and ground nut and two nematicides, viz., DD and Kemagon equally suppressed the population of *Hoplolaimus indicus*, *Tylencho-rhynchus brassicae*, *Tylenchus filiformis* and *Meloidogyne incognita* around tomato, potato and radish. The beneficial effect of these treatments were observed even after a lapse of 6 months when corn, bottle gourd and jowar were grown in the following season.

Alam (1976) in a comprehensive study has proved that oil-cakes were equally effective in two different seasons of India, viz., winter and summer and also in two different soil types, one with high organic content with pH 8.4 and another with low organic content with pH 7.7.
Oil-cakes of cotton seed and pea nut and chicken litter reduced root galling caused by *Meloidogyne arenaria* and stimulate plant growth of *Cucurbita pepo* (Mian and Rodriguez-kabana, 1982a). Soil treatments with oil-cakes was very effective in reducing *Meloidogyne exigua* on coffee (Moraes, 1976). Gowda (1972), Gowda and Shetty (1973), Trivedi *et al.* (1978) and Desai *et al.* (1979) found that different oil-cakes reduced the population of *Meloidogyne incognita* on tomato, chillies and tobacco.

Oil-cakes were also found to suppress the root-knot development and population of other parasitic nematodes on vegetables and perennial crops (Khan, 1969; Khan *et al.*, 1966, 1973, 1974a, b, 1979; Alam and Khan, 1974; Alam *et al.*, 1977a, c; Siddiqui *et al.*, 1976; Bhatnagar *et al.*, 1978 and Janeh and Lambert, 1983).

Khan *et al.* (1976) and Alam *et al.* (1977a) found that the oil-cakes of castor, mustard, margosa and ground nut reduced the population of plant parasitic nematodes in nurseries of *grewia*, *papaya*, *pomegranate*, *mango*, *black berry*, *lemon*, *bougainvillea* and *rose*. Alam (1976) also got satisfactory control of phytonematodes with oil-cakes in the nurseries of vegetables like tomato, *eggplant* and *chilli*. In this way he got tremendous reduction in the cost of application.

Van der Laan (1956) suggested that organic matter alters the host physiology and this results in the host being more
resistant to the development of the nematode within its roots. Alam et al. (1977d, 1980) have established that the plants, grown in oil-cake amended soil, acquire some resistance against the attack of *Meloidogyne incognita* and *Tylenchorhynchus brassicae*. This was also supported by Sitaramaiah and Singh (1978b).

Water extracts of oiled and deoiled cakes and their distillates were found to be toxic to different plant parasitic nematodes (Khan et al., 1966, 1974b; Rao and Prasad, 1969; Deshmukh and Prasad, 1969; Mishra and Prasad, 1973; Sitaramaiah et al., 1974; Pillai et al., 1974 and Alam et al., 1982). High mortality of *Meloidogyne incognita* was achieved by extracts of marotti cake, Karani cake, neem cake and ground nut cake (Desai et al., 1979) and of *M. javanica* by aqueous extracts of margosa cake (Sitaramaiah and Singh, 1977).

**PLAN OF WORK:**

It is evident from the preceding review that considerable work has been done on the effect of organic soil amendments on plant parasitic nematodes. However, there are many facets which need more investigation. For instance, much emphasis has been given to oil-seed cakes and dry crop residues, and that little attention has been given to non-conventional organic amendments. Therefore in the present study some non-conventional organic amendments have been included. Moreover,
their effects in a different mode of application such as bare-root-dip has also been studied in order to evaluate the possibility of systemic activity and for minimizing their cost of application in order to suit different nematode problems. Besides, some chemicals occurring in some of the test materials have been included in the present study for determining their possible role in the control of plant nematodes. In a field study, the effect of organic amendments as such and in combination with ploughing has also been studied. Two nematicides, viz., carbofuran and aldicarb have been included for comparing the efficacy of organic amendments. The following aspects have been studied, the results of which are embodied in the present thesis:

PART 1: EFFECT OF OIL-SEED CAKES/NEMATICIDES AND PLOUGHING:


2. Residual effect of organic soil amendments/nematicides and ploughing on the population of plant parasitic nematodes and plant growth of tomato in field.

PART 2: EFFECT OF MARGOSA/NEEM AND PERSIAN LILAC/BAKAIN:

3. Effect of organic soil amendments with different plant parts of margosa/neem and Persian lilac/bakain on the root-knot development caused by Meloidogyne incognita and plant growth of tomato and eggplant in pots.

4. Effect of organic soil amendments with different plant parts of margosa/neem and Persian lilac/bakain on the population of
Rotylenchulus reniformis and plant growth of tomato and eggplant in pots.

5. Effect of organic soil amendments with different plant parts of margosa/neem and Persian lilac/bakain on the population of Tylenchorhynchus brassicae and plant growth of cabbage and cauliflower in pots.

6. Effect of organic soil amendments with different plant parts of margosa/neem and Persian lilac/bakain on the soil population of nematodes infesting tomato and eggplant in pots.


8. Effect of water extracts of different parts of margosa/neem and Persian lilac/bakain on the hatching of Meloidogyne incognita in vitro.


10. Effect of different chemicals of margosa/neem on the hatching of Meloidogyne incognita in vitro.


14. Effect of bare-root-dip in different chemicals of margosa/neem on the penetration of Meloidogyne incognita larvae into tomato and eggplant roots in pots.

15. Effect of bare-root-dip in different chemicals of margosa/neem on the root-knot development caused by Meloidogyne incognita and plant growth of tomato and eggplant in pots.
16. Effect of bare-root-dip in different chemicals of margosa/neem on the population of the reniform nematode, Rotylenchulus reniformis and plant growth of tomato and eggplant in pots.

PART 3: EFFECT OF LATEX-BEARING PLANTS AND LATICIES:

17. Effect of organic soil amendments with chopped shoots of some latex-bearing plants on the root-knot development caused by Meloidogyne incognita and plant growth of tomato and eggplant in pots.

18. Effect of organic soil amendments with chopped shoots of some latex-bearing plants on the population of Rotylenchulus reniformis and plant growth of tomato and eggplant in pots.


20. Effect of organic soil amendments with chopped shoots of some latex-bearing plants on the soil population of nematodes infesting tomato and eggplant in pots.


22. Effect of some plant latices on the larval hatching of Meloidogyne incognita in vitro.


26. Effect of bare-root-dip in plant latices of Calotropis procera, Euphorbia nerifolia and E. tirucalli on the population of
Tylenchorhynchus brassicae and plant growth of cabbage and cauliflower in pots.

PART 4: EFFECT OF MARIGOLD (Tagetes spp.)

27. Effect of organic soil amendments with different plant parts of marigold (Tagetes spp.) on the root-knot development caused by Meloidogyne incognita and plant growth of tomato and eggplant in pots.

28. Effect of organic soil amendments with different plant parts of marigold (Tagetes spp.) on the population of Rotylenchulus reniformis and plant growth of tomato and eggplant in pots.

29. Effect of organic soil amendments with different plant parts of marigold (Tagetes spp.) on the population of Tylenchorhynchus brassicae and plant growth of cabbage and cauliflower in pots.

30. Effect of organic soil amendments with different plant parts of marigold (Tagetes spp.) on the soil population of nematodes infesting tomato and eggplant in pots.


32. Effect of water extracts of different parts of marigold (Tagetes spp.) on the hatching of Meloidogyne incognita in vitro.

PART 5: MISCELLANEOUS EXPERIMENTS


34. Effect of some nematicides/pesticides on the hatching of Meloidogyne incognita in vitro.