DISCUSSION
Among the different obstacles to the food production in the developing countries, one is the damage caused by different pathogens and pests including plant-parasitic nematodes, where the root-knot nematodes (*Meloidogyne* spp.) occupy a significant position. Their worldwide distribution, extensive host range and disease complexes with fungi, bacteria and viruses make them potentially serious constraints to crop productivity. Most of the plants that account for the majority of the world's food supply are susceptible to infection to one or the other species of root-knot nematodes which are capable of substantially reducing yield and quality of the produce. Vegetable crops such as potato, tomato, eggplant, chilli, okra, etc., being short duration crops, can be cultivated in succession on the same plot. In India as also in many other developing countries, the entire family of vegetable growers work in their small land holdings throughout the year. The monoculture practice is largely responsible for the prevalence, predominance and severity of root-knot disease of these crops.

Several workers have interpreted crop losses due to plant-parasitic nematodes in economic terms. The most recent report, based on comprehensive worldwide survey was given by Sasser and Freckman (1987). They reported a loss of more than $100 billion per annum due to nematodes. This grim situation certainly justifies adoption of proper management of nematodes. Among the various control strategies, chemical control and the recent awareness of their being
potential threat to the environment and health has put a serious question mark on their reliance for future utilization. However, it does not mean that chemicals are useless and should be abandoned. Many of them still have great relevance particularly in integrated pest management programme. A great deal of research has been carried out on nematode control. It involves either the elimination of the nematode pests or the maintenance of their populations at levels below economic threshold where the damage they cause is of negligible economic value.

Indian farmers are mostly illiterate and believe in traditional agriculture, hence do not readily accept the use of nematicidal chemicals to combat nematode menace. Main limitations of the use of nematicides are that they are generally costly and not easily available besides having inherent difficulties in their handling. Therefore, there has been a growing interest in alternate nematode control technologies, use of organic soil-amendments being one of them (Singh and Sitaramaiah, 1970; Alam, 1976; Hasan, 1977; Muller and Goach, 1982). Use of organic wastes, which are available in plenty particularly in the developing countries, for nematode control provides a new channel for their safe disposal.

One of the cheapest and effective methods of altering the soil environment is its amendment with decomposable organic matter. This has been considered as one of the methods of biological control of plant diseases. The materials used for soil amendment include dry or green crop residues and other organic wastes. These materials are allowed to decompose in the field itself where the target pathogens are
supposed to be present. The decomposition of organic matter helps in changing physical, chemical and biotic conditions of the soil. The altered conditions reduce the inoculum potential of the pathogens. In addition, it improves soil structure which promotes root growth of the host. Various chemicals released during decomposition, such as phenols, may induce disease resistance in the roots. Decomposed materials ultimately serve as nutrients for plants and favourably affect the crop yields.

In the present study, efficacy of organic amendments, viz., oilcakes and leaves of neem and castor was evaluated against some most commonly occurring plant-parasitic nematodes. Neem *Azadirachta indica* is a common tree of tropics and its usefulness is multidimensional. In India it is regarded as a miraculous tree. It has been used since time immemorial for medicinal purposes against a large number of ailments. Castor *Ricinus communis* is grown for its invaluable oil which is used in industry as well as in medicine. Leaves of both these plants are not used for cattle feed, therefore the fallen leaves usually go wastes. Their seed cakes are non-edible hence commonly used as manures. Soil amendment with different plant parts or products of neem and castor besides providing nutrients to soil, does not pose any pollution or toxic hazards. More recently extensive work has been carried out with respect to their insecticidal/insect-repellent properties. In case of plant-parasitic nematodes most of the researches are still inconclusive and need further investigation.

The present study embodies three broad aspects related to nematode control: organic soil-amendment, mixed-cropping practice with
antagonistic crops, and integrated nematode management. Cost
effective bare-root dip treatment with plant derivatives and a newer
approach of urea coating with 'Nimin' have also been attempted.
Plants selected for present study represent three different groups
where they occupy prominent positions, e.g., vegetables (tomato,
chilli, potato and okra), oilseed crops (mustard and rocket-salad),
and fodder crops (berseem, rizka and kasni). The results of different
experiments conducted for the present study are discussed here under.

Berseem/Egyptian clover (Trifolium alexandrinum), rizka/
lucerne, alfalfa (Medicago sativa) and kasni/chicory (Cichorium
intybus) are three major fodder crops cultivated in Northern India for
dairy animals. Being members of the family laguminosae the first two
crops also aid in biological nitrogen fixation. However, plant-
parasitic nematodes are limiting factors in their production. Kasni,
considered to be a weed until recently, is now gaining importance as
a fodder crop. Most often it is grown intermixed with rizka and
berseem. Preliminary study revealed that fields having kasni as a
sole crop or intermixed with other crops harboured low populations of
plant-parasitic nematodes. In view of the importance of the above
named fodder crops, a thorough study was undertaken to evaluate the
mixed-cropping practice of kasni with berseem and rizka viz-a-viz
nematodes.

The present study revealed that the populations of Meloidogyne
incognita, Rotylenchulus reniformis and Helicotylenchus indicus
multiplied freely on berseem, indicating that this crop is a good-host
for these nematodes, whereas Tylenchorhynchus brassicae and
Hoplolaimus indicus reproduced only slightly, while Tylenchus filiformis was not supported by the crop. Rizka appears to be a good-host for M. incognita and Hoplolaimus indicus whereas it can be regarded as a poor-host for Helicotylenchus indicus and Rotylenchulus reniformis, and non-host for T. filiformis and T. brassicae. In case of kasni populations of all the nematodes present in the soil declined significantly. The nematode suppressant effects of kasni were noted even when it was grown intermixed with berseem and rizka, thereby showing antagonistic nature of kasni towards the plant-parasitic nematodes (Fig. 1).

Gommers (1973) surveyed members of the family Compositae for locating nematicidal factors and observed several nematicidal principles. Kasni also belongs to the family Compositae. Much work has been carried out on the antagonistic nature of marigold (Tagetes spp.) an important member of Compositae. It has been shown that cultivation of marigold significantly suppressed the population build-up of noxious nematodes (Hackney and Dickerson, 1975). Wallace (1963) suggested that the effects of marigold manifest in the soil, apparently by release of the nematicidal chemicals from the roots. Marigold roots contain considerably high concentrations of \( \alpha \)-terthienyl \((2,2,5,2\text{-terthienyl})\) along with biogenetically related \(5(3\text{-buten-1-ynyl})-2'\text{-bithienyl}\) that exhibited high nematicidal activity against several plant-parasitic nematodes (Zeschmeister and Sease, 1947). There is no report in the literature about the antagonistic nature of kasni as well as its use as a mixed-cropping for the suppression of plant-parasitic nematodes. In all the possibilities the nematicidal of kasni are released along with its
root-exudates as has been shown in case of marigold (Alam et al., 1975).

A similar study was also undertaken to explore scientific basis of another age old practice of growing mustard and rocket-salad intermixed with cereals and vegetables in relation to nematodes. The results of the present experiment indicate that the yield of potato was adversely affected when grown as a sole crop because it supported populations of plant-parasitic nematodes predominantly, *M. incognita* (Fig. 7). Since the cultivation of mustard (*Brassica juncea*) or rocket-salad (*Eruca sativa*) along with potato reduced the population densities of nematodes significantly (Tables 7, 9), the yield of potato should have increased; the failure in the increase of yield (Tables 7, 9) appears to be due to the sharing of soil nutrients by two crops grown simultaneously in the same bed. Although mixed-cropping with mustard or rocket-salad did not apparently improve the yield of potato, the yield of mustard and rocket-salad from the same bed is an additional benefit as both of these are economically important oilcrops. These results are in agreement with those of Alam et al. (1976) who have observed reduction in nematode population on wheat and barley by growing another species of mustard (*B. campestris*) and rocket-salad as mixed crops. Similarly, Mani (1988) observed that interculture of acidlime with mustard (*B. campestris*) reduced the rate of multiplication of *Tylenchulus semipenetrans*. Haq and Gaur (1988) also reported that the interculture of pea and mustard reduced the nematode populations. Mustard (*B. campestris*) was also found to be beneficial in nematode control when included in various cropping sequences (Khan et al., 1976; Alam et al., 1980b, 1981).
The root-exudates of mustard (*B. juncea*) and rocket-salad were highly deleterious to plant-parasitic nematodes (Tables 7, 9) suggesting their role in suppression of nematode populations on potato when grown intermixed with these oil crops. These results confirm and extend the earlier findings of Alam et al. (1976) who have claimed the toxic nature of root-exudates responsible for nematode control on wheat and barley with another species of mustard (*B. campestris*) and rocket-salad. Morgan (1925) noted that the root-diffusates from some crucifers apparently reduced the severity of nematode attack on potato and resulted in increased yield. Similarly white mustard (*B. hirta*) and black mustard (*B. nigra*) showed the same effect (Ellenby, 1945). This effect is considered to be due to the presence of isothiocynates in root-diffusates of these plants (Triffitt, 1929, 1930; Ellenby, 1945). Forrest (1989) and Forrest and Farrer (1983) have also shown that mustard root diffusates were significantly effective in inhibiting the hatching of eggs of *Globodera pallida* previously stimulated by potato root diffusates.

Nematode control efficiency of growing *kasni* with *berseem* and *rizka* as well as mustard and rocket-salad with potato greatly enhanced when beds were also treated with oilcakes and leaves of neem and castor. This type of study, i.e., integration of intercropping with the antagonistic crops and soil application with the organic amendments, has been undertaken for the first time. Neem cake was found to be most efficacious against the nematodes and the effect was almost at par as that for the test nematicide, carbofuran. It was followed, in order of efficiency, by castor cake, neem leaf and
castor leaf (Tables 5, 7, 9). Our results with respect to efficiency of oilcakes are in agreement with those of Lear (1959), Khan (1969), Gour and Prasad (1971), Singh and Sitaramaiah (1973). Alam and Khan (1974). The efficacy of chopped leaves of neem and castor in field has been reported for the first time.

In the present experiments, beneficial effects of oilcakes persisted for longer duration as they remained effective against plant-parasitic nematodes even in the subsequent crop, when a susceptible-crop okra cv.* Pusa Sawani was grown in the same plot without giving any further treatment. Here again the residual effect of neem cake was most pronounced both with respect to nematode control as well as improvement in plant growth (Tables 6, 8, 10). This appears to be due to the fact that oilcakes are made-up of complex organic substances which decompose rather slowly (Daji and Iyengar, 1971), and thus they gradually release nematotoxic substances for longer durations. Similar results have also been obtained by Singh and Sitaramaiah (1966), Mishra and Prasad (1974) and Alam et al. (1977b). Alam (1976) has claimed that oilcakes were cheaper than nematicides and thus provided a favourable cost-return ratio. Regarding the feasibility of using oilcakes, he has provided evidence that these organic additives were equally effective during two different seasons of India, viz., winter (rabi) when temperature ranges between 10-25°C, and summer (kharif) when temperature ranges between 25-30°C and also in two different soil types, one with low organic content and having pH 7.7 and another with high organic content and having pH 8.4.
Basically, different nematode management strategies have their own limitations, though to varying extent. However, Oostenbrink (1972) pointed out that there is a scope of combining different control methods in a complementary manner. Thomson et al. (1983) were of the view that integrated pest management would be the best strategy for nematode management. In order to get maximum benefit it is necessary to have a complete and clear understanding of ecology and biology of crops, pests and their natural enemies. This aspect concerned with the population management but it is abundantly necessary to consider the farmers interest also. Ferris (1978) has rightly suggested that integrated nematode management (INM) concept should be to maximize the nematode management. Various INM strategies have been tried in developed countries with varying degree of success (Webster, 1972; Alphey et al., 1988; Ruelo, 1983). In India also such studies have been attempted (Ravichandra and Krishnappa, 1985; Jain and Bhatti, 1988), though these are basically empirical studies. However, they have atleast opened possibilities of combining different method. Mixed-cropping with different treatments is an integrated approach found to be highly beneficial not only with respect to nematode control but also for improvement of crop yields. The effect of different combinations was more than that achieved by either of the treatments. The integration of these two diversified factors has been studied and reported for the first time.

The mechanism(s) of action of organic amendments leading to plant disease control is not yet fully understood. The complex nature of soil environment makes it difficult to assess the possible activities
occuring in soil. It appears that disease control in amended soil is
the result of not one specific but different factors. These mechanisms
affect disease severity through their effect on soil, host and the
pathogen. Modification of physical, chemical and biotic environment
of soil through addition of decomposable organic matter has been
found to influence incidence of many plant diseases.

Cultural practices employed in biological control encourage
development of such microorganisms in the soil which destroy or
suppress pathogen through antagonism (antibiosis, competition,
parasitism and predation). The metabolites of these organisms or
decomposition products of organic matter attached by them may induce
physiological resistance in the plant.

Many theories have been put forward by different scientists to
explain the possible mechanism of nematode control by the application
of oilcakes to the soil. Alam (1976, 1990b) stated that with liberal
supply of water the oilcakes undergo decomposition and release many
compounds like phenols, aldehydes and different gases including
ammonia. Sitaramaiah and Singh (1978a) also reported the release of
fatty acids, while Khan (1969) and Hasan (1977) have indicated the
release of amino acids and carbohydrates during decomposition of
oilcakes. All these chemicals have been reported highly deleterious to
many plant-parasitic nematodes by many workers (Eno et al., 1955;
Vassalo, 1969; Khan, 1969; Khan et al., 1974a; Walker et al., 1967;
Hasan and Saxena, 1974; Alam, 1976; Sitaramaiah and Singh, 1978b,
Alam et al., 1979 and Badra et al., 1979; Singh and Singh, 1988).
During the degradation of oilcakes there is a possibility of the
release of other chemicals which are detrimental to nematodes. Though it is still premature to say that the amount of these compounds released during decomposition of oilcakes are sufficient for such an action under natural soil conditions. Water extracts of oilcakes and deoiled cakes have also been found toxic to a variety of nematodes (Khan et al., 1966; Rao and Prasad, 1969; Deshmukh and Prasad, 1969; Misra and Prasad, 1973 and Sitaramaiah and Singh, 1977). They also inhibit juveniles hatching probably because they contain varying amounts of phenols, aldehydes and other toxic chemicals of unknown composition (Khan et al., 1966, 1974b; Rao and Prasad, 1969; Sitaramaiah et al., 1974; Pillai et al., 1974; Alam et al., 1978, 1979, 1982). Alam et al. (1982) later got evidence that water soluble fractions of oilcakes became progressively more toxic to nematodes and inhibitory to larval hatching of the root-knot nematode during the course of decomposition. This shows that more toxic principles are liberated during decomposition of oilcakes and form solutions in water and occupy the soil pore spaces where most of the populations of noxious nematodes occur and thus bring about reduction in the inoculum density and keep the nematode populations below the economic threshold levels. Alam (1976) pointed out that due to their high solubility, the toxic fractions can reach into the soil much beyond the rhizosphere region of plants and there kill or limit the mobility of nematodes which are left in the field from the preceding crop. Like nematicides, therefore, they also play a preventive role. Sitaramaiah et al. (1969) have pointed out that oilcakes have adversely affected ovoviviparity resulting in reduced number of infective root-knot larvae in soil.
Addition of organic matter to soil stimulates microbial activity of bacteria, fungi, algae and other micro-organisms (Webster, 1972; Sayre, 1980; Rodriguez-Kabana et al., 1987). Linford (1937) and Linford et al. (1938) used pineapple leaves as soil amendment and obtained significant control of root-knot nematodes Meloidogyne spp. attacking cowpea but noticed an increase in the population of saprozoic nematodes. They suggested that organic amendment supported microbial and animal species inimical to the root-knot nematode. Increased microbial activity in amended soil cause enhanced enzymatic activities (Rodriguez-Kabana et al., 1983) and accumulation of decomposition end products and microbial metabolites which are deleterious to plant-parasitic nematodes (Johnston, 1959; Mankau and Minteer, 1962; Rodriguez-Kabana et al., 1965; Walker, 1971; Khan et al., 1974b; Badra et al., 1979).

As has been pointed out above, the decomposition of oilcakes takes place due to the increased activity of soil microorganisms including bacteria, fungi, etc. The role of fungi during decomposition of oilcakes and its subsequent effect on nematodes has been studied by Kirmani (1977). The metabolites of microbes which become active during decomposition of organic amendments have also shown varying degree of toxicity of nematodes. Culture filtrates of many saprophytic fungi, viz., Aspergillus niger, Penicillium corylophilum have been found to be highly deleterious to plant-parasitic nematodes (Alam et al., 1973; Khan et al., 1981; Kirmani et al., 1978). These fungi are known to produce toxins and
antibiotics-malformin, hedacidine, gliotoxin, viridin and penicillium. In a recent study, Jatala (1986) noted that diffusible metabolites of _Paecilomyces lilacinus_ caused deformation of _M. incognita_. Some microorganisms act as decomposers of organic residues and release substances deleterious to nematodes. These metabolites and decomposition products are quite comparable to nematicides and thus their producers may be considered as bio-control agents. There are several reports about bacteria which produce nematicidal metabolites. Johnston (1959) reported toxicity of culture filtrates of _Clostridium butyricum_ containing formic, acetic, propionic and butyric acids to _Tylenchorhynchus martini_. Rodriguez-Kabana _et al._ (1965) found _Desulfovibrio desulfuricans_ responsible for producing \( \text{H}_2\text{S} \) in enough amounts to control nematodes in flooded rice field. A new group of macrocyclic lactones, called avermectins, have been isolated from _Streptomyces avermitilis_ (Burg _et al._, 1979; Miller _et al._, 1979) and found to be highly toxic to nematodes.

Oilcakes also influence physical and chemical properties of soil (Ahmad _et al._, 1972), which render the soil atmosphere unfavourable for nematode activity. Vander Laan (1956) suggested that the plant host become unfavourable for nematode development due to some possible physiological changes that occur as a result of soil treatment with organic amendments. In case of oilcakes this was proved by Alam _et al._ (1977e, 1980a) and Sitaramaiah and Singh (1978b). They noted increased resistance in plants grown in soil amended with oilcakes. It was suggested that this reduction of
resistance was due to increased level of phenolic contents in the host roots.

Organic additives also release nutrients which accelerate rapid root development and overall plant growth thus helping the plant to escape nematode attack. This theory has been substantiated by the results of another experiment (pot study) where the organic amendments have improved plant weight by several folds (Tables 11-22).

The nematicide-carbofuran was also included in the present study for comparing the efficacy of oilcakes. It was observed that the test oilcakes were in no way inferior to the nematicide (Tables 1-5,7,9).

The principle underlying the efficacy of organic amendments is that the decomposable organic matter should be allowed to decompose in field in such a way and for such a period that the process of decomposition and its associated activities suppress or destroy the pathogen and that it should not interfere with normal cultural practices, and after planting of the crop there is no harmful effect on the plants. Simultaneously, the disease proneness of the plants is also reduced. Since decomposition products of organic matter may harm plant roots, such treatments should be applied some time before planting, hence a waiting period is necessary.

It is very difficult to pin point the exact mode of action of organic additives used in the present study. However, one or the
other reason put forward for other organic amendments may very well be applicable for the present case.

Nematode control efficiency of chopped leaves of some plants, viz., *Azadirachta indica*, *Calotropis procera*, *Melia azedarach*, *Ricinus communis*, *Clerodendrum inerme*, *Eucalyptus citriodora*, *Lantana indica* and *Thuja orientalis* have been evaluated using two doses (50 and 100 g/pot). All these treatments significantly reduced the populations of plant-parasitic nematodes and root-knot development with corresponding increase in plant growth of tomato and chilli (Tables 11-14). Highest reduction in nematode populations as well as root-knot development, and increase in plant growth were found with *C. procera* followed by *A. indica*, *R. communis* and *M. azedarach*, whereas other treatments gave poor results. The effectiveness of different treatments varied from nematode to nematode. Similar results have also been reported by other workers with respect to *A. indica* (Egunjobi and Larinde, 1975), *R. communis* (Zaki and Bhatti, 1990).

Leaf extracts of the above plants also showed high nematicidal property, highest being with *A. indica* (Tables 35-40) thereby substantiating the above results. Similar results have also been reported by others with respect to *A. indica* (Egunjobi and Afolami; 1976; Vijaylakshmi *et al.*, 1979, 1985). Neem (*A. indica*) is known to contain over 34 different chemicals belonging to the diterpenoid, triterpenoid and flavonoid groups (Thakar *et al.*, 1981; Rao and Parmar, 1984). Khan *et al.* (1974b) reported that two bitter principles of *A. indica*, viz., nimbin and thionemone were highly toxic.
to plant-parasitic nematodes. Limonoids belonging to the furanotriterpenoids have also been found to be nematotoxic (Devakumar et al., 1985). U.S. Scientists have developed practical methods for the isolation of azadirachtin and have tested its toxicity against nematodes (Warthen Jr., 1979). Similarly, nematicidal properties were noted in leaf and seed extracts of *M. azedarach* (Lee, 1987). The direct antinemic action showed by the plant extracts in vitro adds credence to the hypothesis of Reninger et al. (1958) with regard to the mechanism of action of organic amendments that the material may be directly toxic to nematodes.

In another experiments, similar results were also obtained with the soil application of fallen leaves of some perennial plants, e.g., neem (*Azadirachta indica*), castor (*Ricinus communis*) and bakain/Persian lilac (*Melia azedarach*). Leaves of neem were found more efficacious than those of castor and bakain. Root-knot development (Tables 17, 18) and nematode populations (Tables 15, 16) gradually decreased and growth of tomato and chilli improved in treating the soil with increasing doses. These additives appear to have toxic principles even in dried form. This type of study with respect to the application of fallen leaves for nematode control has been done for the first time. These finding have also indicated a suitable utilization of fallen leaves, which otherwise remain mismanaged and go waste.

Incorporation of crop residues of marigold (*Tagetes erecta*) mustard (*Brassica juncea*) and sunflower (*Helianthus annuus*) into soil
proved to be highly effective in reducing the incidence of root-knot caused by *M. incognita* (Tables 21, 22) and the population build-up of plant-parasitic nematodes present in the naturally infested soil (Tables 19, 20). Enhanced plant growth of susceptible cultivars of tomato and chilli had positive correlation with the degree of nematode control. Higher doses resulted in better effects (Tables 19, 22). Yuhara (1971) also noted a significant reduction in the population build-up of *M. hapla* by addition of various plant parts of marigold to soil. Mustard and marigold plants are not only antagonistic to the plant-parasitic nematodes (Hachney and Dickerson, 1975; Alam *et al.*, 1976) but their crop residues also possess nematode suppressant properties (Tables 19-22). Therefore, in all the probability stress on plant-parasitic nematodes due to various antagonistic crops may be further enhanced by the incorporation of their plant residues in the field following their harvest (Siddiqui, 1986; Siddiqui and Alam, 1987c, 1988a,b). The present finding with respect to nematicidal nature of sunflower plant residues is reported for the first time. All the additives did not show any phytotoxic effects. The present findings also indicate that the efficacy of different bio-resource amendments is different. Rodriguez-Kabana *et al.* (1987) have concluded that the efficacy of an organic additive depends on its chemical composition and type of microorganisms that develop during the degradation of the additives. This view of Rodriguez-Kabana *et al.* (1987) in a way, fully supports our findings, as marigold plant residue was more effective than mustard and sunflower at the same doses.
Urea is a major source of nitrogenous fertilizer in India. It has been estimated that out of the total quantity of urea applied to crops about 50-70% is lost in various ways thereby reducing the availability of nitrogen to crops. 'Nimin' is a neem product developed indigenously by Godrej Soaps Ltd. for use as urea coating agent to help prevent loss of nitrogen by leaching and ensuring its sustained supply. Since it is a triterpene rich material it should have some antinemic properties. However, nothing is known in this regard. Therefore, present study was undertaken to explore its relevance in nematode control, if any.

The recommended dose of 'Nimin' coatings on urea is 500 g Nimin/50 kg urea (= 1g Nimin/100 g urea). It has been found that, the recommended dose of 'Nimin' is additionally beneficial for the control of plant-parasitic nematodes occurring in naturally infested soil, including root-knot nematode: M. incognita on tomato and chilli (Tables 23, 26). However, the higher doses were more beneficial. All the three doses (1, 2, 3g Nimin/pot) used in the present study have improved plant growth thus showing non-phytotoxic nature of the material at these doses. The nematode control efficiency of 'Nimin' is understandable because neem is already known to be rich in nematode toxic chemicals. The improved plant growth is partly due to the sustained release of nitrogen from urea in presence of 'Nimin' besides inhibition of nematode population. The present study has been done for the first time.

A similar study was also conducted to evaluate nematode control efficiency of oils of neem, castor, mustard and rocket-salad as
urea coating agents. It was noted that these oils have significantly suppressed populations of naturally occurring plant-parasitic nematodes and root-knot incidence caused by *M. incognita* on tomato and chilli. As a consequence of reduction in nematode populations, plant growth enhanced. The different oils proved highly deleterious when doses increased. Here again, neem oil was found to be most beneficial followed by castor, rocket-salad and mustard (Tables 23-26). Nematode control efficiency of oils may be due to the presence of some toxic chemicals as well as fatty acids, etc. that might have released during the break down of the oil.

Oilcakes and leaves of neem and castor have been successfully used in controlling plant-parasitic nematodes when incorporated into the soil (Tables 1-10). However, bare-root dip treatment of tomato and chilli seedlings (both pre- and post-inoculated with *M. incognita*) with extracts of undecomposed and decomposed oilcakes and leaves of neem and castor provided protection against the root-knot disease (Tables 27-34). Thus the extracts exhibited prophylactic as well as therapeutic effects against the nematode. This type of work, in a way, has been done for the first time.

Inhibition of root-knot development was greater in pre-infected seedlings compared with those inoculated with the nematode after root-dip treatment. This indicates that the chemicals absorbed by the roots have directly acted against the nematode already present in the roots. Whereas when the inoculation was made after dip treatment, the potentiality of chemicals might have reduced to some extent by the
time the nematodes had established an effective host-parasite relationship. The present findings also indicate that the water extracts of oilcakes and leaves rendered the roots of susceptible plants highly unfavourable to *M. incognita*. Similar results have been also observed by Siddiqui and Alam (1988c) with bare-root dip of tomato seedlings in undecomposed extracts of neem leaves. They suggested that some chemicals are either absorbed by the roots or their might have been some chain reaction which has been triggered due to some factor ('elicitor'/'activator') present in the leaf extract. Examples of the initiation of cascade mechanism leading to the resistance of cells against the invasion and development of pathogens are available in literature (Bell, 1981; Giebel, 1982). Similar possibilities may well be applicable in the present case. According to Giebel (1982) "The induction of resistance by treating the plants with particular chemicals will perhaps have a great practical significance in the future. Experiments on the chemical induction of a resistant reaction in susceptible plants have not only the practical aspect of perhaps giving a new systemic nematocide. Indirectly, they will enable us to find out new hypotheses or to confirm those already present about the mechanism of plant susceptibility or resistance to nematodes". Kast (1985) also supported these observations that induced defence mechanisms may also have some practical relevance as they may be used in integrated or biological disease control strategies.

The reduction in root-knot development due to root-dip treatment could also be attributed to the unfavourable condition
causing poor penetration and later retardation in biological activities such as feeding and/or reproduction of the nematode as suggested by Bunt (1975).

The extracts of decomposed oilcakes and leaves were found to be more effective than the undecomposed ones. This appears to be due to the release of toxic substances during the course of break down of complex substances as well as production of toxic metabolites by microorganisms associated with the decomposition process.

These findings with respect to the protective action and the direct toxicity of neem and castor would go a long way to help develop some plant based nematicidal products.