MANAGEMENT OF ROOT-KNOT NEMATODE, *MELOIDOGYNE INCOGNITA*, ON OKRA AND LENTIL BY SOIL AMENDMENT WITH OIL CAKES AND LEAVES OF DIFFERENT PLANTS

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Summary. An investigation was undertaken to ascertain the effect of soil amendments with oil cakes of castor and neem and leaves of castor, Persian lilac/bakain and neem, alone and in combination, on *Meloidogyne incognita*, plant growth and chlorophyll content of okra and lentil and *Rhizobium* root nodulation of lentil. In general, all treatments significantly reduced root galling and improved plant growth and chlorophyll content, except when treatment was with castor leaf alone. Performance was improved when the amendments were combined. Neem cakes combined with the other soil amendments gave the best nematode control and plant growth. All treatments increased root nodulation of lentil.

Key words: *Abelmoschus esculentus*, *Azadirachta indica*, control, *Lens culinaris*, *Ricinus communis*.

Plant-parasitic nematodes cause severe damage to crops. There are many reports of crop losses caused by these pathogens in India as well as in other countries (Cairns, 1955; Sasser and Freckman, 1987; Jain and Bhatti, 1978). Control measures are used to minimize the crop losses caused by plant-parasitic nematodes, but some of them have limitations. Several researchers have investigated the use of organic amendments for controlling nematodes (Muller and Gooch, 1982; Rossner and Zebitz, 1987; Alam, 1991), but no-one has investigated the effects of combinations of organic amendments. Therefore, an attempt was made to evaluate the effect of soil amendments easily available in India, such as oil cakes of castor and neem and leaves of castor, Persian lilac/bakain and neem, alone and in combination, on root-knot nematode, *Meloidogyne incognita* (Kofoid *et* White) Chitw. and plant growth of okra and lentil, two important crops in the country.

MATERIALS AND METHODS

A sandy loam soil was passed through a coarse sieve (1-mm-pore size) to remove stone particles and debris, and 1 Kg was put into each of the 15-cm-diameter clay pots used for the experiments. These pots were then autoclaved. Chopped leaves of neem (*Azadirachta indica* A. Juss.), Persian lilac (*Melia azedarach* L.) and castor (*Ricinus communis* L.) at 50 g/pot and their oil cakes at 1 g/N/pot were incorporated separately into the soil of each pot. Combinations of leaves and oil cakes were also tested (Tables I, II), but each amendment was then applied at half of the above doses. To ensure decomposition of the amendments, the pots were irrigated and one week later seeds of okra (*Abelmoschus esculentus* Moench.) cv. Prvani kranti and lentil (*Lens culinaris* Medik.) cv. K-75 were sown. Before sowing, seeds of lentil had been bacterized with *Rhizobium leguminosarum* using 5% sucrose as sticker. After germination, seedlings were thinned to one per pot and then inoculated with 2,000 second stage juveniles (J_2) of the root-knot nematode, *M. incognita*. To obtain J_2s, egg masses of the nematode were collected from infected roots of eggplants, put on a small coarse sieves (1 mm) fitted with moist filter paper, placed in 10-cm-diameter Petri dishes containing 10 ml of water and incubated at room temperature. After 24 hours, the J_2 water suspension was collected and J_2s were counted using counting dishes (Southey, 1986), under a stereo microscope. This nematode suspension was used for inoculation of the plants. Untreated inoculated plants served as a control. There were sixteen treatments (Tables I, II), each replicated three times, according to a completely randomized experimental design. The experiment was conducted on a cemented floor out doors with temperature in the range 20-25 °C.

The experiment was terminated three months after inoculation. Then plants were uprooted, washed gently in tap water and plant growth, chlorophyll content and root-knot index were recorded. The root-knot index was rated according to the scale of Taylor and Sasser (Sasser *et al.,* 1984), in which 0 = no galls per root system, 1 = 1-2, 2 = 3-10, 3 = 11-30, 4 = 31-100 and 5 = >100 galls per root system. Root nodule index was also assessed according to the following rating scale: 0 = no nodules, 1 = 1-10 nodules, 2 = 11-30 nodules, 3 = 31-50 nodules, 4 = 51-100 nodules and 5 = >100 nodules per root system. Chlorophyll content was determined according to the method of Hiscox and Israelstam (1979).

Data were statistically analysed for critical difference according to the method of Pansey and Sukhatme (1978).

Table I. Effect of individual and concomitant application of soil amendments of oil cakes and leaves of different plants on the root-knot nematode, *Meloidogyne incognita*, and plant growth of okra cv. Prvani Krantl.

Treatment	Plant length (cm)			Fresh plant weight (g)			Dry weight (g)			Chlorophyll (mg/g)			Root-knot index (0-5 scale)
	Shoot	Root	Total	Shoot	Root	Total	Shoot	Root	Total	Chl a	Chl b	Total (a + b)	
Castor leaf (CL)	28.2	13.6	41.8	4.3	2.4	6.7	2.0	1.2	3.2	0.356	0.324	0.680	4.0
P. lilac leaf (PL)	28.5	14.8	43.3	4.5	2.5	7.0	2.2	1.2	3.4	0.372	0.333	0.705	3.6
Neem leaf (NL)	29.5	15.8	45.3	4.8	2.6	7.4	2.4	1.3	3.7	0.378	0.336	0.714	3.3
Castor cake(CC)	29.5	16.6	46.1	5.3	2.8	8.1	2.5	1.4	3.9	0.397	0.367	0.764	3.3
Neem cake (NC]	30.4	16.7	47.1	5.4	2.8	8.2	2.7	1.4	4.1	0.399	0.367	0.766	3.0
CL+PL	30.4	17.2	47.6	5.5	2.8	8.3	2.7	1.5	4.2	0.417	0.393	0.810	3.0
NL+CL	31.7	17.3	49.0	5.6	2.9	8.5	2.7	1.5	4.2	0.426	0.391	0.817	2.6
NL+PL	32.0	18.0	50.0	5.7	2.9	8.6	2.8	1.5	4.3	0.444	0.421	0.865	2.3
CC+CL	33.3	18.9	52.2	5.8	3.0	8.8	2.8	1.6	4.4	0.465	0.416	0.881	2.3
CC+PL	33.5	20.8	54.3	5.8	3.3	9.1	2.9	1.6	4.5	0.467	0.450	0.917	2.0
CC+NL	38.1	22.3	60.4	5.9	3.4	9.3	3.1	1.7	4.8	0.488	0.437	0.925	1.6
NC+CL	38.6	23.1	61.7	5.9	3.7	9.6	3.2	1.7	4.9	0.485	0.461	0.946	1.3
NC+PL	38.7	25.0	63.7	6.0	4.2	10.2	3.3	1.9	5.2	0.522	0.456	0.978	1.0
NC+NL	39.0	25.8	64.8	6.2	4.6	10.8	3.3	2.2	5.5	0.547	0.467	1.014	0.6
NC+CC	42.5	27.4	69.9	6.2	4.7	10.9	3.4	2.3	5.7	0.579	0.512	1.091	0.6
Control	26.0	13.3	39.3	3.9	2.3	6.2	1.7	0.9	2.6	0.247	0.150	0.397	5.0
C.D.(P=0.05)	1.92	0.04	2.43	0.45	0.22	0.71	0.25	0.28	0.33	0.052	0.065	0.072	0.76
C.D.(P=0.01)	2.12	1.45	3.28	0.62	0.34	0.96	0.33	0.32	0.44	0.082	0.075	0.098	1.03

Each value is a mean of 3 replicates.
Inoculum level of *Meloidogyne incognita* = 2000 J_2/pot.

Table II. Effect of individual and concomitant application of soil amendments with oil cakes and leaves of different plants on the root-knot nematode, *M. incognita*, and plant growth of lentil cv. K-75.

Treatment	Plant length (cm)			Fresh plant weight (g)			Dry weight (g)			Chlorophyll (mg/g)			Root-knot index (0-5)	Root-nodule index (0-5)
	Shoot	Root	Total	Shoot	Root	Total	Shoot	Root	Total	Chl a	Chl b	Total (a+b)		
Castor leaf (CL)	19.6	11.4	31.0	1.9	1.1	3.0	1.0	0.5	1.5	0.308	0.255	0.563	4.0	1.6
P. lilac leaf (PL)	24.4	16.5	40.9	2.0	1.3	3.3	1.2	0.7	1.9	0.336	0.275	0.611	3.6	2.0
Neem leaf (NL)	25.3	16.2	41.5	2.3	1.7	4.0	1.2	0.8	2.0	0.340	0.276	0.616	3.6	2.0
Castor cake (CC)	26.0	15.8	41.8	2.6	1.7	4.3	1.4	0.8	2.2	0.354	0.314	0.668	3.3	2.3
Neem cake (NC)	28.7	17.3	46.0	2.6	1.8	4.4	1.5	0.8	2.3	0.364	0.316	0.680	3.3	2.6
CL+PL	29.2	18.0	47.2	2.7	1.8	4.5	1.5	0.9	2.4	0.373	0.316	0.689	3.0	2.6
NL+CL	30.4	18.5	48.9	3.0	1.8	4.8	1.8	0.9	2.7	0.390	0.336	0.726	2.6	3.0
NL+PL	30.9	18.5	49.4	3.1	1.8	4.9	2.0	0.9	2.9	0.418	0.371	0.789	2.6	3.1
CC+CL	33.3	18.7	52.0	3.4	2.0	5.4	2.1	1.0	3.1	0.426	0.377	0.803	2.3	3.3
CC+PL	36 0	20.5	56.5	3.7	2.1	5.8	2.3	1.2	3.5	0.446	0.400	0.846	2.0	3.6
CC+NL	37.5	22.3	59.8	3.8	2.2	6.0	2.4	1.3	3.7	0.453	0.408	0.861	1.6	3.6
NC+CL	38.8	23.1	61.9	4.3	2.3	6.6	2.5	1.3	3.8	0.478	0.414	0.892	1.3	4.0
NC+PL	41.1	24.0	65.1	4.5	2.3	6.8	2.6	1.3	3.9	0.470	0.432	0.902	1.3	4.3
NC+NL	42.3	24.3	66.6	4.7	2.4	7.1	2.7	1.4	4.1	0.479	0.433	0.912	1.0	4.6
NC+CC	43.2	24.5	67.7	4.8	2.5	7.3	2.7	1.5	4.2	0.548	0.510	1.058	0.6	4.6
Untreated	19.0	10.7	29.7	1.6	1.0	2.6	0.9	0.4	1.3	0.242	0.172	0.414	5.0	1.3
C.D. (P =0.05)	3.25	2.35	5.33	0.25	0.22	0.65	0.22	0.24	0.25	0.081	0.062	0.092	1.17	0.64
C.D. (P =0.01)	4.76	3.42	7.20	0.36	0.32	0.88	0.29	0.27	0.36	0.110	0.072	0.084	1.56	0.86

Each value is a mean of 3 replicates.
Inoculum level of *Meloidogyne incognita* = 2000 J_2/pot.

RESULTS AND DISCUSSION

In the controls, the root-gall index was maximum (5) for both crop plants, thus indicating that environmental conditions were suitable for nematode infection. All soil amendments used singly and in different combinations reduced significantly the root-gall index caused by *M. incognita* on both plant species (Table I, II) except when castor leaves were used alone. However, the reduction of the root-galling was greater when the amendments were used in combination than when used alone. It was in the range 3-4 with different leaf amendment combinations, 1.6-2.3 when castor cakes were combined with leaf amendments, and 0.6-1.3 when neem cakes were combined with leaf amendments. The least root-knot index (0.6) for both plants was observed in pots treated with a combination of both neem and castor cakes.

Plant growth (fresh and dry weight and plant length) of okra and lentil was improved significantly by all organic amendments except castor leaves (Table I, II). Again, plants grew better when these treatments were used in different combinations. The best growth was observed when neem cakes were combined with the other amendments.

The chlorophyll content of the leaves was also increased significantly by the treatments and was greatest when both crop plants received neem cake combined with the other amendments.

Root nodule index of lentil improved significantly with the decrease of the root-knot gall index (Table II). It was least in the control (1.3) and in the range 2-2.6 when the amendments were applied singly, 2.6-3 with combined applications of leaf amendments, 3-3.6 when castor cakes were combined with leaf amendments, and maximum (4-4.6) when neem cakes were combined with all other amendments.

Our experiment has demonstrated that most of the organic amendments available in India, especially oil-cakes of neem combined with other treatments, are effective in reducing the root-galling caused by *M. incognita* and thereby improving plant growth and increasing chlorophyll content of okra and lentil and *Rhizobium* nodulation of lentil roots. In general, the combinations of soil amendments were more effective than the individual applications, probably because of a positive interaction between amendments. This is the first time that it has been demonstrated that the combination of soil amendments can be more effective than the individual application.

It is clear that, when applied singly, cakes of both neem and castor did not reduce root galling or improve plant growth when compared to single applications of their leaf amendments or leaf of Persian lilac. However, it is also obvious that the combination of amendments is not always more effective, but that the combination of either of the cakes with one of the leaf amendments did reduce root galling and improve plant growth. It is probable that chemical compounds deriving from oil cakes, along with those deriving from the leaf amendments, play a key role in suppressing nematode infection. Oil cakes of neem, castor, mustard and groundnut undergo decomposition in soil and release many components, including ammonia, phenols and aldehydes, the nematicidal nature of which has been demonstrated by many workers (Khan *et al.*, 1974; Alam *et al.*, 1976, 1978, 1979; Goswami and Vijayalakshmi, 1987; Akther and Alam, 1990). The nematicidal activity of neem could be due to any of the several known biologically active principles it contains, such as nimbine, nimbidine, thionemone, kemferol, azidirachtine, etc., which are nematicidal in nature (Khan *et al.*, 1974b; Siddiqui, 1986). Also, these organic amendments stimulate the activity of microbes and production of their metabolites, which are deleterious to nematodes (Walker, 1971; Rodriguez-Kabana *et al.*, 1987). Oil-cake amendments are also known to influence physical and chemical properties of the soil that in turn might affect nematodes and plant growth (Alam, 1976; Sitaramaiah and Singh, 1978; Battacharya and Goswami, 1987). However, the best combinations were those with neem cakes, and especially those with neem or castor leaves. Therefore, these combinations could be sound alternatives for the control of nematodes in India as they would also reduced the cost of application of oil cakes and thus increase the net profit of the crop. However, more investigations are required to define proper rates and timing of application under field conditions of the amendment combinations.

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