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INTEGRATED NEMATODE MANAGEMENT OF ROOT-KNOT NEMATODE

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Integrated Nematode Management may be defined as the integration of management methodologies for all economically important nematodes of the agrosystem, with the objective of optimizing productivity, net returns, stability and environmental quality. It is widely accepted that a management strategy in which a variety of physical, mechanical, cultural, biological and chemical management measures are combined to give a stable, long term nematode management. The concept of integrated nematode control was proposed as early as 1933 by Tyler. The combination of two or more control strategies into an overall management programme is the only sound, sustainable approach to controlling root-knot nematodes effectively

Implementation of INM (Integrated Nematode Management) programme is based on the principles of nematode exclusion, population modifications and tolerance (Bird, 1981). The aim of INM is i) to utilize several compatible control techniques in combination, ii) to maximize natural environmental resistance to plant parasitic nematodes, iii) to apply specific and drastic control measures only as and when necessary, and iv) to maximize profit of the grower with location and resource specific recommendations. The requirements for integrated nematode management are the research, development, transfer of technology for implementation of combining different nematode management options in most effective manner (Bird, 1981). Therefore, the components of INM system includes (a) biological and environmental monitoring (b) agricultural production system, (c) pest crop ecosystem models and system design and implementation (Bird, 1981).

Host Range

M. graminicola, M. naasi, M. oryzae, M. salasi, M. triticoryzae etc. generally prefer cereal hosts but can also infect some dicotyledonous plants (Birchfield, 1965; Yik and

Birchfield, 1979; MacGowan and Langdon, 1989; Gaur and Sharma, 1999; Sabir and Gaur, 2005). The root-knot nematode, *Meloidogyne graminicola* prevalent in most of the rice growing areas of India. *Meloidogyne arenaria* and *M. javanica* are the most constraints to groundnut damage in Gujarat, India (P. Parvatha Reddy). *M. incognita* and *M. javanica* also known to infect in tobacco plants, grapevine. *M. incognita* also known to infect on cotton plants, banana, pomegranate, potato, tomato, brinjal, chilli, okra, French bean, cowpea, peas, carrot, biter gourd, pointed gourd, watermelon, crossandra, tuberose, patchouli, davana, cymbopogon, carnation, gerbera, Coleus forskohlii, Plumbago rosea, kacholam, colocasia, menthol mint, cardamom, betelvine, ginger, turmeric, coriander, cumin, fennel, black pepper (INM, P. Parthava Reddy). *Meloidogyne exigua* and *M. coffeicola* infect on *Coffea arabica*.

Management Strategies

1. Prevention

Preventing nematode problem is far better than trying to treat one after it is established because once a plant is parasitized it is impossible to kill the nematode without destroying the host.

Nematodes which occur throughout the state, may not occur in every site of the area, and it will be worth the effort to avoid bringing any pest into a previously uninfested field. For example, if peanut root knot nematode (*Meloidogyne arenaria*, *M. hapla*, *M. javanica*) is in one of the fields but not in the neighbouring field, we can avoid that serious pest problem into the uninfested field.

This strategy should be the first line of defense. Prevention is the practice of keeping a population of nematodes away from infesting a site and specific tactics include:

- Sampling of soils and plant parts of the suspected field or site to determine the population of existing nematode.
- Use of nematode free transplants or planting materials. Eg. Ornamental cuttings to be rooted should be taken only from uninfested plants or portions of plants above ground, which have never been rooted in a potentially contaminated soil. This prevents propagating populations of root-knot nematodes that might cause serious economic losses.
- Weed control as means of eliminating nematode access to alternate hosts

- Sanitation practices such as cleaning of equipment between sites of operation.

2. Avoidance

It is practiced when nematode populations exist in a site, but their impact can be avoided or lessened through some cultural practice. It includes

- Sampling to determine nematode species and population levels
- Choosing plant materials that are poor hosts.
- Practice crop rotations that include non-host, resistant, and susceptible crops when feasible.

3. Cultural Practices

- Crop Rotation with non-host crops(e.g., for rice rotate with crops like ragi, maize, sugarcane, pulses, castor, cowpea, sweet potato etc. at least for one year). For root-knot nematodes, a resistant cultivar of a susceptible crop can be used in rotation with a susceptible cultivar of the same or different crop in the same way as a non-host crop. Cotton may be used to reduce *M. javanica*, *M. arenaria*, *M. hapla* whereas alfalfa is used to reduce *M. incognita* and *M. arenaria* populations.

Table 1: List of some non/poor hosts of Root-knot nematode that can be included in croprotation (Plant Nematology, N.G. Ravichandra, Chapter 17)

Sl. No.	Target nematode	Non/poor hosts
1.	*Meloidogyne hapla*	Cotton, maize
2.	*M. incognita, M. javanica*	Peanut, mustard, marigold, onion, lucerne, garlic
3.	*M. nasi*	Potato
4.	*M. graminicola*	Potato, groundnut, black gram, wheat, sunflower, soyabean, onion, cauliflower, cowpea

- Summer ploughing 2-3 ploughings at 15-day interval could cause more than 70% reduction in nematode population density. The efficiency of summer ploughing is improved by polythene mulching that trap and retains solar heat for longer period, thereby reducing the population. Root-knot can be effectively control by this method.

- Rabbing is another method to raise root knot nematode free seedlings. After ploughing the nursery area to a fine tilth, a 15-20 cm thick layer of rice husk (20kg/sq.m) can be spread on the surface and burnt. The practice of rabbing tobacco seedbed with paddy husk reduces the root-knot nematode population.
- Flooding has long been practiced for the control of root knot nematodes; this practice may be uneconomical but effective against root knot nematodes on vegetables.
- Organic manuring-Incorporation of rice straw into the soil resulted in a significant decrease in the population density of root knot nematodes and improve the yield. Growing mungbean and ploughing back the green crop after picking pods significantly reduced the infestation in subsequent rice crop. Green manuring by growing and ploughing back *Sesbania aculeate* or *Sesbania rostrata* also reduced the population. Chopped pineapple leaves, *Sorghum vulgare*, Neem leaves, water hyacinth, decaffeinated tea waste, chrysanthemum can also be used.
- Adjustment of sowing/planting dates and season- The planting of winter annual crops, usually in autumn, can be delayed until soil temperature has declined, to avoid nematode activity. Thus if a host crop of *M. incognita* is planted after the soil temperature has declined below 18ºC, the plants will escape the infection**.**

4. Trap Crops/ Antagonistic Crops

In plants like Crotolaria, the root knot nematodes invade but fail to reach maturity. Such plants can be used to trap the nematode juveniles before planting the actual crop.

On the other hand, antagonistic crops (enemy crops) which contains some chemicals or alkaloids can be used to repel or suppress the nematode.

Table 2: Important plant possessing nematicidal effect on Root-knot nematodes. (Plant Nematology, N.G. Ravichandra, Chapter 17)

Sl. No.	Scientific name	Common name	Plant part
1	*Tagetes* spp.	Marigold	Root
2	*Azadirachta indica*	Neem	Seed, leaf
3	*Brassica* spp.	Mustard	Seeds
4	*Lantana camara*	Lantana	leaves

5. Host-Resistance

Some root knot nematode resistant lines/cultivars reported from India

- **Tomato**: Karnataka hybrid, Hisar-1, Hisar-N-2 &3, Mangla Hybrid, Hisar Lalit
- **Pea**: C-50, A-70, B-58
- **French bean**: Banat, Blue Lake, Brown beauty, Cambridge
- **Rice**: Badami, Neela, Bhanja, KAU-28-1-1,
- **Groundnut**: Ambali 4018
- **Coffee**: Coffea robusta, C. arabica
- **Potato**: Kufri Deva
- **Chilli**: Pusa jwala, Pusa sadabahar, ca-63
- **Okra**: Arka Anamika
- **Tobacco**- Motihari, Bitri, Hepti

6. Biological Control

Organic amendment of root knot nematode infested soil is highly effective due to their nematoxicity, imparting tolerance to plants and encouraging build-up of natural antagonists. However, requirement of very high dosages and cost considerations deter their use at field scale. Nevertheless, products like Neem cake, Neem seed extract, Lemon grass oil etc can be used for nursery bed treatment, spot application and basin area treatments in different crops.

Oviparasitic fungi, *Paecilomyces lilacinus* and *Pochonia chlamydosporia*; and a bacterial parasite, *Pasteuria penetrans* are promising biocontrol agents. Bacterium *Pseudomonas fluorescens, Bacillus thuringiensis* and fungi like *Trichoderma harzianum* and *T. viridae* have also been found effective.

7. Chemical Control

Nematicides are generally not recommended, particularly in vegetables crops, in view of their high cost and residue problem in fruits. However, intensive cultivation of high value susceptible crops makes their use unavoidable. The following methods are recommended for judicious use of nematicides

- Treatment of nursery bed alone with carbofuran @3kg a.i. per hectare in case of transplanted vegetable crops at sowing.
- In case of bold-seeded crops like okra cucurbits, cowpea etc, seed dressing with carbosulfan @ 2-3% W/W
- Seedling root dip treatment of vegetables crops in thionazin 500 ppm for 15 mins or carbosulfan 1000 ppm for one hour.
- All these practices are very effective to give initial protection to the young vulnerable stage of crop.
- In case of grapevine, application of carbofuran @4kg a.i. perhectare just before pruning is highly effective.
- For *M. graminicola* infecting rice, nursery bed treatment with carbofuran @ 0.1 g a.i per sq.m and field application of carbofuran @1kg a.i per ha 40 days after transplanting rice helps in checking the disease. Soaking of rice seeds in 0.1 percent solution of carbosulfan 25 EC is also effective.

Conclusion

Once an area has been infested with root knot nematode systemic adoption of INM is necessary. The great challenge is to control the nematodes in soil and root tissues. Therefore, no single method maybe sufficient to avoid significant damage due to root knot nematode. Depending upon the crop, a combination of two or more practices can be employed to raise successful crops in infested areas. Developing resistant cultivars, they can be incorporated in the rotation/succession are highly encourage especially for *M. incognita*. Also, the search for nematicides with greater control efficiency is needed. New registration for safer nematicides have increased in the recent years, and this trend will increase in view of the worldwide for less toxic pesticide. In addition, the use of biocontrol fits perfectly in INM, which further favours the scenario of root-knot nematodes in the coming years.

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