National Symposium

on

Recent Advances and Research Priorities in Indian Nematology

9 - 10 December 2005

ABSTRACTS

Compiled by

Gautam Chawla
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Organized by

Nematological Society of India

and

Division of Nematology

Indian Agricultural Research Institute, New Delhi – 110 012

Website: www.nemaindia.com

Virulence and Molecular Diversity of Root-Knot Nematodes Infesting Tomato in Meerut Region

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Studies were conducted on the virulence and molecular diversity of *Meloidogyne* spp. infesting *Lycopersicon esculentum* (Linn.) (Tomato) in Meerut region. Root samples were collected from the naturally infected agriculture fields during 2005. The parasites were cultured in experimental earthen pots and in agar gel plate both. Identification at the level of species was done with the help of PCR. The primer used was as described by Stantion *et al* (1997). The PCR performed 45 μl of master mix. Amplification was processed by 30 cycles of 30 minutes at 94^0C. Agrose (1.75%) gel electrophoresis was carried out in TAE. DNA fragments approximately 400, 450 and 600 base pairs indicating the pooled infection of *M. incognita, M. arenaria* and *M. javanica* respectively that was visualized with Ethidium Bromide in gel documentation system. The virulence of all the species was observed as *M. incongita >> M. javanica > M. arenaria.*

Amino Acid Profile of Dominant Ectoparaisitc Phytonemas Infesting Economically Important Plants of Garhwal Himalayan Region

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Biochemical study has been conducted on *Hoplolaimus indicus, Helicotylenchus indicus* and *Tylenchorhynchus brevilineatus* infesting some of the economically important plants *viz*. *Pinus roxburghii, Prunus persica, Pyrus malus, Citrus aurentium* and *Eucalyptus globules* grown in the soils of Uttaranchal state at different altitudes i.e. 450, 650 and 1900m Above Sea Level (ASL). Total 19 amino acids were detected from all the studied nematodes. The common amino acids were detected as - analine, aspartic acid, cysteine, cystine, glutamic acid, glycine, histidine, hydroxyproline, isoleucine, leucine, ornithine, phenylalanine, proline, serine, threonine and tyrosine. Isoleucine was the only exceptional amino acid that occurred in *Hop. indicus* at 1900±100m ASL whereas amino butyric acid and 3,4 dihydroxyphenylalanine were the exceptional amino acids detected in *Hel. indicus* at the same altitude. Threonine and tyrosine were very unusual amino acids detected in *T. brevilineatus* at 650±50m ASL while glutamic acid and ornithine were detected exceptionally at 1900±100m ASL from the same nematodes.

Studies on Morphometic Variation within the Population of *Heterodera zeae* in Rajasthan

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An intensive survey was carried out during *Kharif* 2004 and *Rabi* 2004-05 in different agro climatic regions of Rajasthan. A total of 415 plant root and soil samples were collected from different localities to study the morphometric variations within the population of *Heterodera zeae*. Body dimension of second stage larvae, cyst length, cyst width and vulval cone top characters were taken in to consideration. On comparison of body dimensions of the populations recovered with the original description of species it was observed that most of the dimension of vulval cone top characters was within the range. However, in some population, characters like vulval bridge width, underbridge length & width showed variations. It was upto 37.80 % in width of vulval bridge toward higher side, variations in under bridge length was 3.87 % towards lower side, whereas, in under bridge width it was 7.58 % towards higher side. Cyst length of few population of *H. zeae*, showed variation up to 13.50 % toward lower side. In regards to the body dimension of second stage larvae the characters like body length and stylet length found more variable than other characters observed. The variation in body length was 2.22 % towards higher side whereas; variation in style length was upto 1.68 % towards higher side when compared with the original description of the species. The variations in body dimension of second stage larvae and vulval cone top characters may be due to varied soil type, prevailing temperature conditions, soil moisture, preceding crops and many such other abiotic and biotic factors.

In Vitro Mass Multiplication of Entomopathogenic Nematodes

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The mass multiplication (*in vitro*) of *Steinernema* sp. (STSIRO) and *Heterorhabditis* sp. (HMABU) was conducted on different artificial media i.e. wheat bran + salad oil; dog food agar medium; yeast extract + soyflour + egg + lard; and modified egg yolk medium. The infective juveniles of *Steinernema* sp. (STSIRO) and *Heterorhabditis* sp. (HMABU) were inoculated in petridishes @ 1000 IJs / petridish. It was subsequently observed that IJs were found capable to multiply on both plant and animal protein media. Maximum number of IJs of *Steinernema* sp. (STSIRO) 2.2 x 10^5 were obtained modified egg yolk medium followed by yeast extract + soyflour + egg + land 0.252 x 10^5. Similarly, in case of *Heterorhabditis* sp. (HMABU) maximum number of IJs 6.182 x 10^5 were recovered from modified egg yolk medium followed by yeast extract + soyflour + egg + lard number of IJs 0.557 x 10^5. No production of EPNs was however, recorded in wheat bran + salad oil and dog food agar medium. The IJs of *Heterorhabditis* sp. (HMABU) multiplied better on artificial media as compared to *Steinernema* sp. (STSIRO).

The Host range and Mass Multiplication of *Steinernema* sp. (STUDP-2) and *Heterorhabditis* sp. (HUDP-2) in Laboratory conditions

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Host range of entomopathogenic nematodes *Steinernema* sp. (STUDP-2) and *Heterorhabditis* sp. (HUDP-2) was tested in laboratory on different lepidopteran and coleopteran insect pests *viz*., greater wax moth (*Galleria mellonella*), diamond back moth (*Plutella xylostella*), spotted boll warm (*Earias vitella*) and white grub (*Phyllophaga* sp.). Among these, *G. mellonella* and *P. xylostella* were found highly susceptible against both the genera of EPNs. Whereas, *E. vitella* and *Phyllophaga* sp. were found comparatively less susceptible. For mass multiplication of *Heterorhabditis* sp. (HUDP-2) and *Steinernema* sp. (STUDP-2) rice moth *Corcyra cephalonica* (Stainton) was used. Both these entomopathogenic nematodes were multiplied on the larvae of *C. cephalonica*. The IJs of *Steinernema* sp. (STUDP-2) harvested were 42342, 51702 and 67112 from small, medium and large sized larvae, respectively. Similarly IJs of *Heterorhabditis* sp. (HUDP-2) harvested were 58210, 85027 and 97219 from small, medium and large sized larvae, respectively. The number of IJs of EPNs harvested further increased with an increase in size and body weight of the insect larvae.

Integrated Management of Root Knot Nematode, *Meloidogyne incognita* in Chilli

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Field trials were conducted in farmers field at Coimbatore to evaluate integrated management practice for the management of root – knot nematode, *M. incognita* in chilli cv. K_2 with physical, cultural and chemical components of soil solarization, neem cake and carbofuran application. The results showed that, soil solarization of nursery bed for 3 weeks with LLDPE of 100 gauge thickness followed by application of carbofuran3G@ 10g / m_2 in the nursery and main field application of neemcake @ 500 kg / ha significantly increased the chilli yield by 63.1% and reduced *M .incognita* population in soil and root by 53.3% and 67.7% respectively over control. The cost:benefit ratio was 1:2.8.

Management of Root-Knot Nematode, *Meloidogyne incognita* in Tomato by Soil Solarization and Resistant Varieties

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Field trials were carried out to study the effect of soil solarization along with growing resistant (Hisar lalith) and susceptible (PKM 1) varieties of tomato in farmers field at Coimbatore. The results revealed that, solarized nursery bed sown with resistant variety of tomato recorded lowest nematode population in soil and root by 65.3% and 78.7% respectively over control. The yield was increased by 56.5% over control and the cost:benefit ratio was 1:2.7. While the plants grown in non solarized nursery bed with susceptible variety of tomato recorded highest nematode population in soil and root and lowest yield.

Evaluation of Fly Ash-Extract on Hatching and Mortality of Root-Knot Nematodes

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For the experiments, fly ash was collected from Thermal Power Plant, Kasimpur, Aligarh. Fly ash-extract was prepared by adding one litre double distilled water to one Kg fly ash and left for overnight. Egg masses and juveniles of *M. incognita* and *M. javanica* were obtained from the pure populations maintained in culture bed separately. After filtration different dilutions (0, 20, 40, 60, 80, 100 %) were prepared.For hatching experiment, five average sized egg masses of *M. incognita* and *M. javanica* were placed in petridishes containing different dilutions. Each treatment was replicated five times. Hatched juveniles were counted at different intervals (1, 3, 5 and 7th day). For mortality experiment, 100 juveniles of *M. incognita* and *M. javanica* were transferred separately to each dilution and dead juveniles were counted at different intervals (1, 3, 5 and 7^{th} day) . Data were analyzed statistically for significance. All the concentrations of fly ash-extract significantly impaired the hatching of *M. incognita* juveniles as compared to control at all time intervals. Inhibition in hatching was directly proportional to the concentration of fly ash-extract. Hatching was completely checked at 100% fly ash-extract concentration, in all days. Similar results in hatching of *M. javanica* juveniles were also observed. However, the effect of fly ash-extract concentration was slightly greater on *M. javanica* as compared to *M*. *incognita.* As a result, hatching was more in *M. incognita* than *M. javanica*. Similarly all the fly ash-extract concentrations were harmful to *M. incognita* juveniles. Killing of juveniles was started from 1^{st} day to 7^{th} day. As concentration was increased, the killing percentage of juveniles was also increased. Highest mortality (%) was observed in 7^{th} day with 100 % fly ash-extract concentration. Thus mortality was directly proportional to the concentration as well as number of days increased. Similar results were also observed with *M. javanica* juveniles.

Study of Sulphur Dioxide Effects on Seed Gall Nematode, *Anguina tritici* on Wheat

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The present study was carried out to observe the interactive effect of different concentrations of sulphur dioxide (0.05, 0.1, 0.2, 0.4 ppm) with different inoculum level (2,500, 5000, 10,000) of seed gall nematode, *Anguina tritici* on morphological (plant growth and yield) and biochemical (photosynthetic pigments, carbohydrate contents and protein contents) parameters of wheat (*Triticum aestivum)* under artificial condition in glass house. The SO_2 and *A. tritici* interacted antagonistically. Three sulphur dioxide doses (0.1, 0.2 and 0.4 ppm) were harmful to all plant growth (length, fresh weight. dry weight. no. of tillers, leaf area), yield (length of ear, no. of grains/ear, weight of 100 grains), photosynthetic pigments (chl a, chl b, total chl 'a+b' and carotenoids), carbohydrate contents (soluble and insoluble carbohydrate) and protein contents (soluble and insoluble protein) of wheat and killed the nematodes. However, 0.05 ppm concentration of SO_2 caused less reduction in all above parameters compared to control but was able to kill the nematodes. Only few seed galls were produced in plants inoculated with higher level of nematodes (10,000) and exposed to 0.05 ppm of SO_2. If lower doses of SO_2 (0.05ppm) apply to wheat crop field infected with *A. tritici t*he loses may be minimize.levels of nematodes, 0.05 ppm SO_2 was able to kill them.

Community Analysis of Plant Parsitic Nematodes associated with Agriculture Crops In Junagadh District of Gujarat and Diu- Union Territory

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An extensive survey was conducted in Junagadh district of Gujarat and Diu, an union territory, in onion, garlic, wheat, brinjal, castor, cotton, coconut and flowering plants to access nematode status. Five plant parasitic nematodes viz., *Rotylenchulus reniformis, Helicotylenchus* spp., *Tylenchorhynchus* spp., *Meloidogyne* spp., and *Pratylenchus* spp. were isolated and identified from soil and root samples collected from rhizosphere of host crops. Out of these, the highest frequency of occurrence was recorded in *Helicotylenchus* spp. (40.91) followed by *Tylenchorynchus* spp. (36.36) in Junagadh district. While in Diu, the highest frequency (70.0) was of *Meloidogyne* spp. recorded followed by *Pratylenchus* spp.

Management of *Meloidogyne incognita – Sclerotinia sclerotiorum* disease Complex on *Mentha arvensis* through Chemicals, Organic Amendments and Bioagents

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A pot experiment was conducted to manage the *Meloidogyne incognita – Sclerotinia sclerotiorum* disease complex on *Mentha arvensis* cv. Gomti through chemicals (carbofuran @ 33.5 mg a.i./kg and bavistin @ 2 mg a.i./kg), organic amendments (neem seed powder @ 50 mg/kg, neem cake @ 50 mg/kg, mint manure @ 1500 mg/kg, farm yard manure @ 1500 mg/kg and *Murraya koenigii* leaves powder @ 500 mg/kg) and bioagents (*Trichoderma harzianum*, *Pseudomonas fluorescens*, *Paecilomyces lilacinus*, *T. virens* and *Aspergillus niger* @ 50 mg/kg soil with 10^8 cfu/g). All the treatments showed significant effect in improvement of all the growth parameters of the plants as well as on disease suppression. Among all the treatments applied carbofuran was found to be most effective followed by neem seed powder, neem cake and bavistin. Among all the biocontrol agents *T. harzianum* was found to be highly effective, however response of *T. harzianum* was found almost equal to that of bavistin.

Evaluation of Bio-Inoculants, Organic Amendment Materials and Pesticides for the Management of *Meloidogyne incognita- Fusarium solani* Disease Complex of Brinjal Cv. Pusa Kranti

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Studies were made to determine the effect of bio-inoculants viz., *Aspergillus niger, Paecilomyces lilacinus, Trichoderma harzianum, T. virens* and *Pseudomonas fluorescens* @ 50 kg/ha each containing 10^8 cfu/g culture, organic amendment materials viz., neem (*Azadirachta indica*) seed powder @ 100 kg/ha, fresh leaves of neem (*A. indica*) and murraya (Murraya koenigii) @ 300 kg/ha each, farmyard manure and mint (*Mentha arvensis*) manure @ 1500 kg/ha each, and pesticides viz., carbofuran and topsin-M @ 2kg a.i./ha each for the management of *Meloidogyne incognita* (@ 4000 J2/4 kg soil) and *Fusarium solani* (@ 10 g/4 kg soil containing 10^6 cfu/g culture) disease complex of brinjal cv. Pusa Kranti under pot conditions. Results revealed that all the treatments significantly improved the plant growth and reduced the percent root infection and root knot index as compared to untreated inoculated control except the treatment with farmyard manure. *T. harzianum* was found most effective in improving the plant growth followed by *T. virens, A. niger, P. fluorescens, P. lilacinus*, carbofuran, neem seed powder, topsin-M, neem leaves, murraya leaves and mint manure respectively. Highest root-knot index (2.75) and fungal infection (47.5%) were observed in untreated inoculated plants.

Parasitism of Nematode and Soil fungi in Brinjal and Tomato

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An extensive survey was carried out for infestation of Nematode and Soil fungi in tomato and brinjal at vegetable research farm of the University. Soil samples from rhizosphere of infective crop plants of tomato and brinjal were collected for laboratory study. Some soil fungi like *Rhizoctonia solani, Fusarium oxysporum, Pythium aphanidermatum* and *Phoma specials* were encountered causing in 20 to 28 per cent infection in green brinjal varieties / cultures. *Melodogyne Javanica* and *M. incognita* were isolated from the infected root samples of brinjal and tomato, root knot nematode was having infection 76 to 100 per cent in Kalyanpur round brinjal, Whereas, the infestation ranges from 11 to 51 per cent in hybrids. Green brinjal cultures expressed 0-10 per cent infection. All these pathogens caused considerable damage to tomato crop except one. *Phoma specials.* Root knot nematode was not more severe in tomato as in brijal. The reaction of root knot nematode was noted moderately resistant in green brinjal cultures. Viz. KS-326, B.G.L. 31 and in tomato verities/ cultures viz. ARTH-3, ARTH-164, JKTH-895, ARTH-43, BSS-98, BSS-175, SUN-176, SUN-230. *Meloidogyne spp., Heterodera sp., Tylenchorhynchus spp., Rotylenchulus reniformis, Helicotylinchus dihystera, Trichodorus spp. Tylenchulus sp.* were recorded in filed soil samples where these two vegetable crops were grown.

Effect of *Rhizoctonia solani – Fusarium oxysporum – Meloidogyne incognita* Disease Complex on *Vigna radiata* and its Management through Integrated Approach

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Mungbean (*Vigna radiata*) has been reported to suffer severe losses due to various pathogens alone as well as in disease complex. In field mostly it encounters with the disease complexes rather than a single pathogen. Therefore, pot experiments were conducted to determine the effect of *Rhizoctonia solani*, *Fusarium oxysporum* and *Meloidogyne incognita* in sequential as well as in concomitant inoculations on the growth of mungbean cv. PDM-139 and management of this disease complex through bioagents (*Trichoderma harzianum*, *Aspergillus niger*, *Pseudomonas fluorescens*) and botanicals (*Azadirachta indica* seed powder and *Murraya koenigii* seed powder) in separate as well as in combined treatments. Results showed that all the pathogens caused significant reduction in combination as well as in either of these pathogens alone. Highest reduction in shoot height, root fresh weight, root dry weight, shoot dry weight and seed weight was observed in plants inoculated with *R. solani*, *F. oxysporum* and *M. incognita* simultaneously and least reduction when plants were inoculated with *R. solani* alone. It was also observed that prior inoculation of *R. solani* and *F. oxysporum* inhibits the reproduction of *M. incognita*, whereas prior inoculation of *M. incognita* supported the root colonization by both the fungi. Out of the several combinations of bioagents and botanicals tested in full and half doses, *A. indica* seed powder (half dose) + *T. harzianum* (half dose) and *T. harzianum* (half dose) + *P. fluorescens* (half dose) were found to be most effective in improving the growth parameters as well as in managing the disease complex as compared to other combined treatments, whereas, *A. indica* seed powder (half dose) + *M. koenigii* seed powder (half dose) was found least effective among treatments but was quite effective as compared to untreated inoculated plants.

Effect of *Panagrolaimus* fuchsi Ruhm on mycelial growth, flush pattern and sporophore yield of *Agaricus bisporus* (Lange) Imbach and nematode multiplication

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Experiment was conducted to elucidate the relationship between population dynamics of saprophagous nematode *Panagrolaimus fuchsi* and different parameters of mushroom growing. The nematode showed a potential to effect various vital parameters of mushroom cultivation. The data revealed quantitative losses in presence of this nematode. The nematode at lower population did not show any effect on mycelial growth but at high counts some degenerative effect on mycelium was observed. Total sporophore yields were adversely affected in the treatments receiving high nematode inoculum of 10^6 or 10^7 level. Quantitative losses to the tune of 26.0 per cent were recorded when 10^7individuals of *P. fuchsi* were inoculated at spawning and casing time. Sporophore production ensued late in nematode infested bags (at and beyond 10^5 level) and cropping ceased early, thus reducing the total cropping period. Flush pattern was immensely disturbed and flush gap period in severely infested bags was reduced to the level that buttons appeared almost regularly in small quantities and not within the obvious flushes. This was in sharp contrast to the uninoculated bags where sporophores appeared in low and high numbers in clear succession of flushes at the duration of 7-9 days with second flush yield in the maximum button production. Nematodes multiplied rapidly in compost as well as casing medium and a multiplication rates of 284, 220, 102 27.2 and 26.5X were recorded against respective initial inoculum of 6.6, 66.6, 666.6,6666.6,and 66666.6 nematodes. *Panagrolaimus* also had an adverse effect on the quality of buttons. Nematode symptoms on the fruiting bodies appeared in the form of unhealthy look, whiteness turning towards brown, notched, misshapen, kidney shaped and distorted sporophores.

Use of Fungi *Trichoderma* spp. and *Paecilomyces lilacinus* as Bioagents for the Management of Root - Knot Nematode *Meloidogyne incognita* infecting blackgram (*Vigna mungo*)

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Among pulse crops in India blackgram (*Vigna mungo*) is widely grown, covers 24 million hectares of land area under cultivation and contributes 12 million tones production annually to the Indian economy. Although root – knot nematode is a recognized pest of leguminous crops, limited work has been done on this nematode pest infecting blackgram in Rajasthan. So, an attempt has been made to test the efficacy of biocontrol agents, *Trichoderma* spp. against *Meloidogyne incognita* infecting blackgram by applying *Trichoderma* spp. at two different inoculum levels (15gm ; 30gm).The nematophagous fungi *Paecilomyces lilacinus* was given at a particular dose to control the disease.
In another set of experiment inoculum application frequency of *Trichoderma* spp. was tested and also of *Paecilomyces lilacinus* against *Meloidogyne incognita* infecting blackgram. *Trichoderma* spp. were inoculated at regular intervals of 30 days and 60 days along with *Paecilomyces lilacinus*. In both the sets of experiments there was an improvement in plant vigour in all the treatments where biocontrol fungi (*Trichoderma* spp.) were applied.

Role of *Caenorhabditis elegans* (Maupas) Dougherty in the cultivation of White button mushroom *Agaricus bisporus* (Lange) Imbach

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Sampling of various mushroom growing components viz., wheat straw, compost, casing soil, platform soil, chicken manure and spent compost from a farm at Solan (HP) revealed the prevalence of saprophytic nematode *Caenorhabditis elegans* (Maupas) Dougherty in extremely high populations (1,40,000 /100 g) in the casing soil collected from the cropping beds. No significant mycelial depletion was observed at casing in the bags inoculated with 10^4, 10^5 or 10^6 individuals at spawning. However, a decline in sporophore production of *Agaricus bisporus* (Lange) Imbach was observed at the inoculum level of ten nematodes per gram of compost or beyond. Interestingly, nematodes added to casing caused more quantitative damage as compared to those added to compost at spawning. Button production declined by 14 per cent when the nematodes were inoculated @ 10^6 individuals per ten kg compost and by 27 per cent at inoculum level of 10^6 nematodes per five kg of casing. Nematode multiplied rapidly in the cropping beds and the multiplication rate of *C. elegans* was more when inoculated at casing as compared to those inoculated in compost at spawning. These results indicate casing to be the more suitable medium for thriving of *C. elegans* as compared to compost. Qualitative damage in the form of morphological distortion and browning especially in the gill region of some of the Infested sporophores was also observed. Such sporophores, when washed, showed the presence of *C. elegans* on their body.

Yield Loss Potential of Foliar Nematode, *Aphelenchoides besseyi* in Tuberose

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A field experiments was conducted at Horticultural Research Station of Bidhan Chandra Krishi Viswavidyalaya, Mondouri, Nadia with two treatments viz. treated i.e. pre-soaking of bulbs in plain water for overnight + hot-water treatment at 50^0C for 30 minutes + three sprayings with monocrotophos 36SL at 500 ppm at 15 days interval (repeated the same spraying in second year from March onwards) and untreated control plots with ten replications to estimate the yield losses caused by the foliar nematode in tuberose under field situations. Experimental results showed clearly that the treated plot showed low nematode infestation (26%) and PDI value (25%), reduction (53%) of nematode population and higher spike yield (mean 286/plot) as compared to untreated plots (mean 207/plot). With the adoption of nematode management practice, spike yield could be saved up to 38% and that could be to the extent of 59% when loose flower yield/plot was taken in consideration.

Field Efficacy of Chemical, Botanical and Biological Agents against Foliar Nematode, *Aphelenchoides besseyi* infecting Tuberose in West Bengal, India

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A field experiment was conducted at Central Research Farm of BCKV, Nadia, India with the treatments comprising of monocrotophos 36SL at 500 ppm (T_1), carbosulfan 25EC at 750ppm (T_2), cartap hydrochloride 50WP at 750 ppm (T_3), NSKE 10,000 ppm (T_4), *Pseudomonas fluorescens* at 2 g/litre of water (T_5), farmers' practice (T_6) and untreated control (T_7) to test the efficacy of chemical, botanical and biological formulations for managing foliar nematode problem in tuberose. Experimental results showed that incorporation of different formulations significantly reduced nematode attack as compared to untreated plots. The application of monocrotophos 36SL at 700 ppm as bulb treatment for six hours followed by four foliar sprays at 15 days interval significantly reduced nematode disease in tuberose. The nematode infestation ranged from 29% to 55% in the untreated plot whereas in all the treated plots the infestation level was recorded low (14% to 37%) and the lowest (14% to 29%) infestation was observed in T_1. The average number of flower stalk was the highest in T_1 which was followed by T_2, T_3, T_4 and T_5. The PDI value varied from 13 to 36 in the treated plot, 26 to 48 in farmers' practice and 29 to 53 in the untreated plots. The nematode population per flower stalk was found maximum (mean population density 3403/flower stalk) in the untreated plots as compared to the treated plots. Considering overall performance of the treatments, T_1 was the best treatment which was followed by T_2, T_3, T_4 and T_5. In terms of C-B ratio, T_1 ranked first followed by T_5, T_4, T_2, T_3 and T_6. The information generated through this investigation could be useful to produce tuberose flower free of pesticides particularly by restricting use of chemical pesticides for bulb treatment.

Management of Root-Knot Nematodes in Bitter Gourd using Organic Amendments

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The root-knot nematodes, *Meloidogyne* spp. are key pests, causing heavy losses in bitter gourd when grown in sandy loam soils under irrigated conditions. Only few chemical nematicides are available in the market and are costly as well as create residue problems. An experiment was conducted for management of the root-knot nematodes in the crop using different organic amendments viz. Neem cake, Mustard cake, Dry Azolla each @ 2 t/ha and Poultry manure, Pressmud each @ 3 t/ha following Randomized Block Design with four replications in 2.0 m x 4.5 m plots with crop spacing of 1.5 m x 1.0 m on local variety Surati. Carbofuran- a chemical nematicide was tried as a treated check for comparison. The organic amendments were applied in spots ten days before sowing to allow decomposition. The results indicated significant differences in root-knot index and bitter gourd yield due to various treatments. Highest yield with lowest root-knot index was observed in mustard cake treatment followed by poultry manure treatment. Carbofuran was at par with control in respect to yield.

Development of Resistant Varieties for a Viable Method for Control of Cereal Cyst Nematode, *Heterodera Avenae*

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The cereal cyst nematode, *Heterodera avenae* Woll. is a soil born parasite of barley, wheat, oat, rye and *Chinopodium* causing heavy losses in wheat growing area of northern India. To combat this disease a array of chemical, cultural practices, biological agent, soil amendments, plant extract were tried and some of them found effective against this nematode but every treatment have their own merit, demerit and limitation but other hand resistant cultivars proved very effective, easy to apply with low input cost and get higher production. After screening of many exotic germplasm resistant source found in wheat i.e. AUS 15854. This resistant gene of cultivar used in hybridization with seven common & commercial varieties by simple pedigree method. Selected crosses of these rigorously tested for resistance in natural & artificial infested conditions. Cross combination of J-24, Raj 3077 and Kalyan sona found resistant while crosses of Raj 2184, Raj 2329. Raj 2535, HD 2009 found susceptible against Jaipur population of *H. avenae.* The resistant plants of cross combination were tested natural infested field. Resistant line of J 24 x AUS 15854 gave higher yield, better grain quality and more straw yield as compare to other crosses. Resistant line procured in bulk & further tested at Agriculture Training Center, Krishi Vigyan Kendra, Agricultural Research Station & released as a resistant cultivar of wheat namely Raj MR-1 for Northern Eastern Plane.

Prevalence of Root Knot Nematode Species In Rajasthan and Some New Host Records.

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To found out the prevalence of root knot nematodes in various districts of Rajasthan, a survey was carried out in 59 tehsils of 25 districts from where 758 samples were collected. Survey studies revealed that 70.40 percent incidence predominantly occurred on vegetables while some other weeds also found infested with this nematode. Root knot nematode populations in vegetable fields were recorded up to 6.20-larvae/ ml soil. *Meloidogyne incognita* was found pre-dominant in 15 districts while *M. javanica* was predominant in 10 districts. *M. arenaria* was found only in Sriganganagar district where groundnut based cropping was common. Kota and Baran districts were having very limited infestation of root knot nematodes. Mustard, kanteli and Kala Dhatura were observed for the first time infested with root knot nematodes in Rajasthan. *M. incognita* species was identified on mustard. Large number of weeds like *Chinipodium album, C. murale*, satyanashi, *Cypers rotendus* etc. were observed heavily infested with root knot nematodes which increasing nematode population in fields in even in absence of crops.

Status of Ear cockle Disease (*Anguina tritici*) in India

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Ear cockle disease of wheat caused by *Anguina tritici* cause qualitative and quantitative losses in some states of Northern Western and Northern Eastern plane zone of India. To find out exact situation of disease in India, a survey studies was carried out by various center of AICW&BIP. About two and half thousand grain samples were collected from Punjab, Haryana, Rajasthan, Bihar, Madhya Pradesh, Maharashtra and Himachal Pradesh. Presence of this disease was only observed in Bihar and Rajasthan state. In Rajasthan 456 grain sample were collected from various district shown that 7.67 % samples infested with this disease and highest infestation was recorded from Tonk district with infestation range (percentage) 0.05 to 2.2. In Bihar, highest infestation was observed in Harpur block of Samastipur district with 66.66 infested samples. Average percentage sample infested was recorded 1.36 in studied states with average infestation range percentage 0.05 to 2.2. Four-year survey results revealed that 4.19 percent samples of wheat were found infested with ear cockle nematode in Rajasthan having 1.33 percent seed infested with galls. Wheat yield losses in term of rupees were 1.43 crore was observed in Rajasthan alone.

A Preliminary Report on the Relative Abundance of Dorylaimida, Tylenchida and Mononchida Population of Guava Orchards in 24 Parganas, West Bengal, India

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An attempt was made to investigate the relative abundance of dorylaimid and tylenchid fauna in relation to mononchids of two separate guava orchards in South 24 Parganas district, West Bengal. One of these is a private garden at Shalipur (West) and the other is the Experimental Agricultural Farm of Calcutta University, Balarampur, both situated in Baruipur Subdivision, just 25 kms away from Kolkata Metropolis. In the former orchard, the population of four genera of Dorylaimida, two genera of Tylenchida and three genera of Mononchida were accounted at every one month interval from May, 2004 to October, 2005, whereas, in the later orchard population of three genera, one genus and three genera of the above mentioned orders respectively were estimated in the same time gap. In the study of population fluctuation, the total populations of the each already mentioned group were counted without analyzing the individual genus or species.

In Shalipur (West) orchard, the population of dorylaimids and tylenchids were boosted in the month of July along with the population of mononchids. But in rest of the whole year soil and phytophagus nematodes maintained a low average with little fluctuations, being minimum in the month of April. But the populations of predatory nematodes are fluctuating considerably throughout the rest of the year with a significant peak in the month of October also. In case of population studied from Calcutta University Experimental Farm, maximum range of boosting of population for all three groups, occurred in July. In rest of the year, the rate of population growth of dorylaims and tylenchs in relation to mononchs is inversely proportional to some extent. The data of population figures are shown and correlations between change of population of Dorylaimida and Tylenchida with that of Mononchida are illustrated.

Effect of Humic Acid on Root – Knot Nematode, *Meloidogyne incognita*

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Different concentrations of humic acid (0.2% to 1%) were tested for their influence on egg hatching and juvenile mortality of *Meloidogyne incognita in vitro*. Humic acid at all the concentrations tried, caused significant inhibition in egg hatching and caused cent percent inhibition of egg hatching at 1% concentration. The per cent J2 mortality of *M. incognita* increasing with per cent concentration of humate showed positive relationship. It is optimized that humic acid at 0.4% is effective to cause higher juvenile mortality (93%) with comparatively shorter period of exposure (48h).

Role of Bioagents in Management of *Pratylenchus thornei* infesting Chickpea

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Chickpea (Cicer *arietinum* L.) is an important crop in pulses and occupies a large area in central U.P. Presence of nematode population in soil aggravates production of wilt and root rot in chickpea in sandy loam soil and causes loss to the yield. Earlier experiment had been conducted with bioagent supplied in soil and found effective. But due to its high dosages of application and keeping problem, another experiment was conducted with application as seed treatment in a naturally infested field of *Pratylenchus thornei* (INP- 340 l /200 cm3 soil). Seven treatments were applied viz., T1- *Pseudomonas fluorescens* 5 g/kg, T2- *Pseudomonas fluorescens* 10 g/kg, T3- *Trichoderma viride* 5 g/kg, T4- *Trichoderma viride* 10 g/kg, T5- T1+T3, T6- Control (carbosulfan 3%) and T7- control (untreated). Observations were recorded for produce and final nematode population at maturity of crop and incidence of wilt and root rot was also noticed.

It had been observed that combined treatment with fungus and bacterium (T5) had better management results in comparison to single application. The produce was increased up to 29.5 % and FNP was reduced 22.3% in comparison to untreated control. Incidence of disease was also less in treated plots. Thus application of bioagents in small quantity can be recommended in integrated nematode management practices for better response.

Bacteria: A Potential Bioagent against Root-Knot Nematode, *Meloidogyne incognita*

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Plants carry a wide range of micro organisms in their phyllosphere and rhizosphere which cause large variety of diseases. Nematodes form an important niche in agro- ecosystem. They cause reduction in plant productivity and growth. *Coriandrum sativum* is an important spice crop and Rajasthan is a leading state in area and production. But this crop is harmed severly by *M. incognita.* So some agent is required to check this pest. Indiscriminate use of chemical pesticides causes great harm to human being, animal, vegetation and to environment as a whole due to their non target effect, hazardous nature besides they are expensive. So with the increasing awareness of possible deleterious effects of the chemicals, biological controls of plants pathogen have received considerable attention. To control the pathogen different strains of bacteria *viz*. *Pseudomonas fluorescens. Bacillus* f*irmus* and *Bacillus subtilis* were used as bio agents. . *P. fluorescens* was multiplied on Kings B medium while *Bacillus* spp. were multiplied on nutrient broth. Two sets of experiments were set up to find out the effect of different inoculum level (5ml and 10 ml) and inoculum sequence (10 days prior, simultaneously and 10 days after the pathogen inoculation) on plant growth. After 90 days plant growth parameters were measured and optimum dosage and sequence of bioagents for inoculation in soil was determined. Greatest increase in plant growth characters like root length, shoot length, fresh and dry weight of root and shoot was recorded for the treatment of *P. fluorescens* at the dose of 10 ml/pot when treatment was given 15 days prior to nematode inoculation.

Integrated Nematode Management of Cereal Cyst Nematode, *Heterodera avenae* in Wheat

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A field experiment on INM of *Heterodera avenae* was conducted at CCN infested (7.2 l/g soil) cultivator's field near to Jaipur. The treatment consisted of vermin compost (5.0 Ton./ha), *Trichoderma viride* and *T. harzianum* (4.0 g/kg seed), alongwith treated check (carbofuran 3G @ 1.5 kg a.i./ha) and untreated control. Besides this, the combination treatment of vermicompost + *T. viride* +1/2 dose of carbofuran (0.75 kg ai/ha) was also included for evaluation. The highest yield of 37.66 g/ha was obtained with the treatment of treated cheek, which found to be *at par* (35.50 g/ha) with that of the combination of vermicompost + *T. viride* + 1/2 dose of carbofuran. Both these treatments have reduced CCN population upto 1.76 and 2.26 cysts/plant over the untreated control (3.52 cysts/plant) respectively. The treatment of *T. harzianum* did not show any marked effect for managing the *H. avenae.*

Pathogenicity, Host range and Foraging behaviour of *Heterorhabditis indica*, *Steinernema siamkayai* and *S. asiaticum* strains indigenous to Haryana

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Strains of *Heterorhabditis indica* (from Dist. Mahendergarh) and *Steinernema siamkayai* and *S. asiaticum* (from Dist. Hisar) were isolated by '*Galleria* trap' method and *in vivo* cultures were raised on the same host. Pathogenicity on *Galleria mellonella* larvae and host range tests were carried out *in vitro* by filter paper method. Mortality by all the three nematode species was cent percent in *Pieris brassicae* (after 48 h) and *Agrotis ipsilon* (after 24 h) whereas it was 10, 40 and 80% by *S. asiaticum*, *S. siamkayai* and *H. indica*, respectively in *Helicoverpa armigera* (after 48 h). *H. indica* though killed the insects, yet no IJs were produced; whereas *Steinernema* spp. multiplied well. On *G. mellonella*, mortality by *H. indica* was 100% at 30 C, 6.6 at 25 C and 53.3% at 20 C after 48 h which increased to 100% only after 120 h of exposure. IJs at 25 C could be recovered only after transferring to 20 C. Average yield of IJs at 30, 25 and 20 C was 101586, 127799 and 150650 per insect larva, respectively. In case of *S. siamkayai* 100% mortality was achieved after 72 h at all the three temperatures whereas in case of *S. asiaticum* only 93.3, 93.3 and 86.6% mortality at 30, 25 and 20 C, respectively was recorded after 120 h. Though emergence of IJs was delayed by 4 days at 30 C and 20 C, the IJ yield per larva was not affected. Bioassay for foraging behaviour indicated ambushing in both the *Steinernema* spp. and cruising in *H. indica*.

Field Evaluation of Bacterial Parasite, *Pasteuria penetrans* as Nursery Bed Application against Root-knot Nematodes, *Meloidogyne javanica* on Brinjal

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Root-knot nematodes (*Meloidogyne* spp.) are a serious threat to vegetable cropping system, and brinjal is one of the most susceptible hosts. The endospore-forming bacterial parasite – *Pasteuria penetrans* of root-knot nematodes has been reported very promising and was subjected to field test. Brinjal (cv BR-112) nursery was raised in *Meloidogyne javanica*-infested soil (Pi = 6-8 J2/g soil). *P. penetrans* was applied to nursery soil at two dosages i.e., PP-I (1 x 10^4 spores/g soil) and PP-II (1 x 10^5 spores/g soil). Nematode-free soil (H), untreated nematode-infested soil (N) and carbofuran @ 2 kg a.i./ha (C) served as checks. Four-week-old seedlings were transplanted at two field sites (one each in Mahendergarh and Fatehabad districts, Haryana). At Mahendergarh field test, treatments with PP-II, PP-I and C significantly increased yield by 45.9, 26.1 and 38.1%, respectively over N. All treatments reduced galling, and least gall index was recorded in PP-II. Similar trend was noticed in final J2 population. At Fatehabad, the gall index and final J2 population were significantly reduced by PP-II and PP-I. Yield increase was maximum in PP-II (58%), while PP-I (18.1%) and C (16.6%) were on par, but significantly higher than N. It is inferred that nursery soil treatment with *P. penetrans* at 1 x 10^4 spores/g soil gives good results on par with carbofuran treatment, while at 1 x 10^5 spores/ g soil, it is even better than nematicidal treatment.

Test for Interbreeding between *Heterodera avenae* and *H. filipjevi*

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For studying mode of reproduction and possibility of interbreeding between *Heterodera avenae* and *H. filipjevi*, an experiment was done with Mahendergarh (*H. avenae*) and Kangra populations (*H. filipjevi*) during first year and with Udaipur population (*H. avenae*) and Punjab population (*H. filipjevi*) in second year. Perspex vials (30cc capacity) were used for this purpose. The vials were cut open at the bottom, and other end was closed with screw cap. Single seed of WH283 wheat was sown in each vial filled with steam-sterilized soil. Five days after sowing, when roots reached to the bottom, cap was unscrewed and freshly hatched larva(e) were inoculated near root and cap was placed again. Inoculation was done in five combinations viz., one J2 of *H. avenae*/vial (T1), two J2 of *H. avenae*/vial (T2), one J2 of *H. filipjevi*/vial (T3), two J2 of *H. filipjevi*/vial (T4), and one J2 each of *H.avenae* and *H. filipjevi* / vial (T5). There were 30 vials for each treatment. after 120 days of inoculation, soil was processed through 100 mesh sieve for cyst extraction. Results revealed that cysts were formed only in vials wherein two larvae of *H. avenae* (T2) or *H. filipjevi*(T4) were inoculated. No cysts were recovered from treatments T1, T3 and T5. Thus both *H. avenae* and *H. filipjevi* reproduce by amphimixis only, and interbreeding does not take place between these species.

Survey on the Occurrence of Root-Knot Nematode, *Meloidogyne graminicola* in Rice Nurseries

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A survey was conducted to find out the occurrence of root-knot nematode, *Meloidogyne graminicola* in rice nurseries, having heavy textured soil in a village Pipli of Sonepat district (Haryana) during July, 2005. Plants alongwith roots were uprooted from nursery beds and observed for the presence of galls. Out of 25, plants in 14 nursery beds were found infected with *M. graminicola*, representing 56% of the samples infestation. The roots were heavily galled, the galls were hooked shaped, white in colour and terminal in position. Present observation indicates high occurrence of this nematode in nurseries. Hence, it is essential to use nematode free healthy seedlings to avoid spread to new areas.

Standardization of Techniques for Screening Wheat and Barley Varieties against *Heterodera avenae*

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Evaluation of crop germplasm against phytonematodes is an important step in breeding programme. Experiments were carried out to standardize techniques for screening wheat and barley varieties against *Heterodera avenae*, in screen house and field. In first experiment, *H. avenae*- resistant and susceptible varieties of wheat (C306 and WH147 susceptible; Raj MR1 and AUS 15854 resistant) and barley (Varde and Rika susceptible; Drost, BH393 and RD2035 resistant) were taken. Four seeds of each variety were sown in thermo Cole pots containing 150 cc infested soil (5 eggs and J2 / cc soil). Two plants per pot were maintained. Observations were recorded on root swellings (knotting) and cysts/ females per pot, 40 and 80 days after sowing, respectively. In both the crops, root swellings at penetration sites were more in susceptible than in resistant varieties. In susceptible wheat varieties (C306 and WH147) stub formation of roots occurred due to nematode infection which was absent in susceptible barley varieties (Varde and Rika). In Raj MR1, swellings with branching occurred at infection site. In AUS15854 wheat, root swellings were fewer and smaller than Raj MR1. Roots of resistant barley varieties Drost and BH393 showed swellings and branching at infection sites but roots of RD2035 showed comparatively very small swellings without any branching. Cysts were formed only in susceptible varieties of both the crops and their number was more on barley (55 and 90 on Varde and Rika) than wheat (20 on both C306 and WH147).Thus, root swellings and branching of roots are not reliable criteria for judging resistance or susceptibility to *H. avenae* in wheat and barley. In another experiment, 14 lines of durum wheat (P7178, P7191, P7192, P7197, P7198, P7199, P7200, P7201, P7202, P7205, P7209, P7210, P7214, and P7217) were sown in clay pots (having infested soil) and in sick-plot. At 100 days of sowing, plants were evaluated according to the scale used in AICW&BIP. From pots, cysts were extracted by processing the entire soil. In sick-plot, plants were taken out along with earth ball, with the help of a *khurpi*. The soil from the root system was gently removed by tapping, collected on a polythene sheet and processed for cyst extraction. The females attached to root system were counted with hand lens.

Average number of cysts per plant on different varieties varied between 50-95 in pots, 5-21 on root system and 24-101 in soil. By considering the cysts on root system only, one variety fell in highly susceptible, five in susceptible and eight in moderately resistant categories. While taking in to account the cysts from soil, all the 14 varieties were categorized as highly susceptible, as also under pot conditions. This suggests that pot screening is better than field screening and that in field, varieties should be evaluated carefully.

Influence of Crop Sequence on the Population of Root-Knot (*Meloidogyne incognita*)

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Okra as main kharif crop was sequenced by different rabi and zaid crops viz., Garlic - cluster bean, potato - onion, chickpea - tomato (resistant), fenugreek - tomato(resistant), mustard - brinjal, wheat - cucurbit, wheat - fallow and brinjal - okra at Jabalpur (M.P.) showed that the population of root knot (*Meloidogyne incognita*) increased in potato, chickpea, fenugreek, onion, cluster bean, cucurbits and brinjal by 16 to 200 per cent while decreased to the tune of 8 to 57 per cent in wheat, mustard, tomato (resistant) and garlic. Maximum reduction of nematode (57%) was noticed in wheat.

Hatching of Rice Root-Knot Nematode at Different Temperature Levels

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Rice has its peak growth period during July and August months (Ambient Temp. is 35°-40°C) while. December and January are the growing months for wheat (Ambient temperature 12°C-18°C). With so such variation in temperature requirement of the two crops the same nematode species is able to infect the both. Keeping this point into consideration egg hatching of *M.graminicola* was recorded at different temperature regimes. The experiment was conducted in the month of September. Four temperatures i.e. 13.5°+1°C, 20+1°C, 25+1°C and 31+1°C were selected for the study. Two hundred and fifty eggs of *M.graminicola* were placed on a tissue paper supported by wire net in a petri-plate. Petriplates were kept in the incubator run at the above mentioned temperatures. Data on egg hatching were recorded after ovary 48 hrs. of placement of eggs in the incubator. It was observed that the hatching continued upto 20th day of placement of eggs at 13.5+1°C and 20+1°C temperature regimes while it continued upto 18th day at 25+ 1°C and 31+1°C temperature levels. The maximum hatch (91.66%) was observed at 31+1°C and minimum (72.11%) was at 13.5+1°C temperature. Hatching range at different temperature levels were 72.11 to 91.66%. Maximum hatching percent at all the temperature levels occurred upto 10th day which ranged between (62.2% to 66.76%) . At 13.5 +1°C and 20+1°C the hatching was at decreasing trend starting from 24.15% and 29.78% for 13.5°C and 20°C respectively and ending at 0.44 and 0.48% respectively. However, no such trends were observed at the higher temperature levels wherein hatching dropped suddenly on 4th and 6th day of placement of eggs and later on the hatching was at increasing trend. At these two temperatures hatching was complete by 18th day of placement of eggs. Unhatched eggs were lowest (8.34%) at 31°C temperature and highest (27.89%) at 13.5°C.

Occurrence of *Meloidogyne graminicola* on Weeds Growing in Rice Nursery

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During the survey of rice root knot nematode, *Meloidogyne graminicola* in rice nurseries in village Pipli of Sonepat district (Haryana) during July 2005, several nurseries were found to be infected with *M.graminicola*. Weeds growing in these nurseries were uprooted and examined for the presence of galls. Weeds viz. *Echinochloa colonum* (Family Gramineae), *E.crusgalli* (Gramineae), *Panicum repens* Gramineae) *Cyperus esculentus* (Cyperaceae) and *Phyllanthus niruri* (Euphorbiaceae) are reported to be highly infected with *M.graminicola*. Out of these, *P.repens*, *C.esculentus and P.niruri* are reported new hosts from Haryana. These weeds, as alternate hosts play an important role in multiplication and survival of this nematode during rice growing season.

Population Dynamics of Root-Knot Nematode under Different Cropping Sequences at Farmers Fields.

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The study was carried out to ascertain the fluctuation of *Meloidogyne* spp. in different cropping sequences adopted by the farmers at two sites in Barwala and Gabipur villages of Hisar district in Haryana. At the village Gabipur the farmer used cotton and Gram crops during the first three years (2001-02 to 2003-04) and cotton wheat in the year 2004-05 whereas at the other village the farmer had taken vegetable crops only. The population root-knot nematode was recorded at sowing and harvesting of the crops. The results revealed that population of the nematode fluctuated between 180 J2 to 340 J2/200cc soil during the first three years in cotton- gram rotation at Gabipur village and root knot index at harvesting tissue ranged between 3.4 to 4.0 on these crops. But during the year 2004-05, the final nematode population at the time of harvesting of cotton crop though increased from 235 - 270 J2/200cc soil but was reduced by 48.5% by taking wheat (non-host) in that field.
At Barwala village, where the farmer had taken vegetable crops at his field only, the population of root-knot nematode multiplied very fast (320 J2 to 660 J2/200 cc soil) within a year by taking highly susceptible brinjal and okra crops. During the second year the population declined sharply to 160 J2/200 cc soil by keeping the soil fallow from April to September months and taking non host onion crop from September onwards. Root-knot index on this crop was 1.0. Further during February-March, there was 12.3% increase in population by taking susceptible tomato crop (cv. Maharshi hybrid). During the year 2003-04, the nematode population reduced further from 180 J2 to 58 J2/200 cc soil by keeping the field fallow from May to October and taking less susceptible potato crop. In the year 2004-05, the population of nematode in May increased to 160 J2/200 cc soil on long melon crop with a root-knot index of 2.3. The population decreased further to 100 J2/200 cc soil in October, 2004 by keeping the field fallow and taking potato crop and was further increased by 60% by taking tomato crop during February, 2005. The study of the population fluctuation of root-knot nematode at both the sites clearly revealed that increase in the population of root-knot nematode (*Meloidogyne* spp.) is comparatively more by taking susceptible vegetable crops as compared to susceptible field crops.

Effect of Biocontrol Agents on the Population of *Pratylenchus thornei*

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Soil application of *Trichoderma viride* @ 2.5 kg/ha, *T. harzianum* @ 2.5 kg/ha, *Pseudomonas fluorescens* @ 2.5 kg/ha and simultaneous application of *P. fluorescens* and *T. viride* and *P. fluorescens* plus *T. harzianum* separately influenced the population of *P. thornei* significantly over control. *P. fluorescens* plus *T. harzianum* and *T. viride* separately decreased the population and increased the yield considerably as compared to control. Both the treatments reduced the soil and root population by 76 and 68 per cent during 2004 and 70 and 64 per cent during 2005. There was increase in yield by 17 and 25 per cent during 2004 and 24 and 28 per cent during 2005. Next in efficacy was *T. harzianum* during both the years.

Level of Awareness of Phytonematode Problems of Wheat in Hisar and Fatehabad Districts of Haryana : A Case Study.

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Wheat being the most important rabi crop of Haryana, attacked by various insect pests, pathogens and also by two important species of phytonematodes namely *Anguina tritici* (wheat seed gall nematode) and *Heterodera avenae* (cereal cyst nematode). A need was felt to ascertain the extent of knowledge of the common farmers about the prevalence of these diseases in the wheat fields Fatehabad and Hisar districts of the state. This being more important because of their hidden mode of life, small microscopic size and nonspecific above ground symptoms on plants in spite of their common occurrence in their fields. A systematic study was undertaken to know the level of knowledge of the farmers about symptomatology and management strategies of these diseases. The study was based on randomly choosen 250 farmers of these districts during various transfer of technology activities organized by the university during 2001 to 2004. The information on symptoms of these diseases, their prevalence in their fields and their control was collected on a specially designed questionnaire.

Interesting facts were revealed by this study enumerating that the specific symptoms caused by earcockle and tundu diseases at the vegetative phase(basal swelling of the stem, increased tillering and stunted growth etc. were not explained by any of the farmers. However, 27 farmers out of 250 explained about crinkling curling twisting symptoms on leaves. Further 42 farmers could diagnose the typical cockled earheads, whereas none could diagnose the symptomless cockled earheads. Surprisingly,all the farmemrs were well versed with the tundu disease symptoms on the earheads caused by association of *Anguina tritici* and *Clavibacter tritici*. A total of 198 farmers out of 250, did not recognize 'mamni' as nematode cockles but mistook these as weed seeds. In spite of the enormous efforts to educate the farmers about the simple method of water flotation techncique to remove the mamni from wheat seeds before sowing, it was surprising to note that only 20 farmers out of 250 showed the necessity to clean up the wheat seeds for removing 'mamni' before sowing.

In the similar study on molya disease caused by *Heterodera avenae*, all the farmers (250) confounded the above ground symptoms on the wheat plants viz. yellowing of leaves, stunted growth and poor tillering etc. with malnutrition and stress symptoms. However, 50 farmers specifically identified the typically bushy root symptoms of the disease. As regards the management of this disease all the farmers were not aware of the control measures of this disease. However, 50-60% farmers were following the practice of rotation of wheat crop with mustard crop in the cropping sequence inadvertently in these areas. Similarly 20% of the farmers do deep summer ploughings in the months of May and June without specifying the impact of this practice on the management of molya disease. The present study reveals high level of ignorance of the farmers of these two districts about the earcockle, tundu and molya diseases of wheat in spite of the fact that large number of fields are infested with the molya disease. Further, it implies that rigrous efforts need to be undertaken by all extension agencies using all the modern methods of transfer of technologies to disseminate the knowledge of these diseases and their management among the farmers.

Host Status of Different Seed Spices against Root-Knot Nematode (*Meloidogyne incognita*).

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Spices are aromatic dried roots, bark,buds, seeds, berries or other plant parts. Besides their use in costemetics, perfumery, confectionery and medicines they are rich source for flavour and tasty food. In Haryana state seed spices viz. coriander, fenugreek, fennel and cumin etc. are grown as rainfed and irrigated crops. An attempt was made to study the host status of commonly grown seed spices against *M. incognita*. The experiment was conducted under screen house conditions in sandy loam soil infested with *Meloidogyne incognita* having initial nematode population of 1.3 J2/cc soil. Seeds of ten available genotypes of methi, five of fennel, four of coriander and twenty of cumin were sown in pots of 15 cm diameter during Nov.,2004. One plant was retained one week after germination. All the treatments consisted of 3 replications. The observation on root-knot index was recorded 90 days after sowing. The results revealed that methi was found to be highly susceptible with an average root-knot index of 4.6 followed by coriander (3.7). Cumin showed moderate response but fennel showed very poor response on all the varieties with a root-knot index ranging from 1-2 only as compared to 4.7 on susceptible tomato as a check.

Efficacy of Fungal Antagonists in the Management of *Meloidogyne javanica* in Cowpea as Seed Treatment.

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A screen house study using 15cm earthern pots was undertaken to see the efficacy of two fungal antagonists viz., *Trichoderma viride* and *Gliocladium virens* as seed treatment against root-knot nematode, *M. javanica* infesting cowpea. The seeds of a susceptible cowpea variety were treated with laboratory propagated fungal cultures (spores and mycelia) @ 5 and 10g/kg seed before sowing and subsequently root-knot nematode inoculation @ 1.0 J_2/g soil was done one week after sowing. The results indicated that the growth parameters of cowpea plants, i.e; shoot length, fresh and dry shoot and root weight, were maximum and significantly higher in plants treated with *T. viride and G. virens* @ 10g/kg seed followed by carbosulfan seed treatment (3% a.i. w/w) as compared to their lower dose i.e., 5g/kg seed and untreated check which showed minimum and significantly lower plant growth parameters. The results of *T. viride* @ 10g/kg seed were statistically at par with 10g dose of *G. virens*. Nematode multiplication in terms of number of galls and egg masses was significantly reduced in carbosulfan followed by *T. viride* and *G. virens* @ 10g/kg seed as compared to their lower dose and untreated check. Final soil population of J_2, however, showed non-significant differences.

Management of *Meloidogyne javanica* by a Bacterial Antagonist, *Pseudomonas fluorescens* as Seedling Root Dip in Tomato.

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A preliminary screenhouse study was conducted to see the efficacy of a bacterial antagonist, *Pseudomonas fluorescens* (Pf-1) as seedling root dipping in its aqueous formulation @ 1.0,2.0 and 3.0 per cent (w/v) dose/dilution. The healthy and root-knot nematode infested tomato seedlings were root dipped in 1.0, 2.0 and 3.0 per cent dilutions for ½ hour and then transplanted in *M.javanica* infested soil in 15 cm pots under different set of experiments. The results obtained 45 days after transplanting revealed that root dipping of healthy (no galls) tomato seedlings was effective in enhancing plant growth as well as reducing nematode galling and fecundity at 2.0 and 3.0 per cent dose of *P. fluorescens* as compared to untreated check. The percent reduction in galling over untreated check was 32.8, 29.6 and 6.4 at 3.0, 2.0 and 1.0 per cent dose, respectively. Similar trend was observed in respect of egg masses and final soil population of J_2. Similarly, in another set of experiment, root-knot nematode infested (galled) tomato seedlings dipped in aqueous formulation of *P. fluorescens* indicated that as compared to healthy seedlings, root dip was not much effective in reducing nematode multiplication. The per cent reduction in galling over untreated check was 19.0, 18.0 and 9.0 at 3.0, 2.0 and 1.0 per cent dose/dilution of *P. fluorescens*. Similar trend was also observed with number of egg masses and final J_2 population in the soil.

Nematicidal Activity of Various Medicinal and Aromatic Plants under *in vitro* Conditions

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Nematicidal efficacy of various medicinal and aromatic plants, viz., mulhatti (*Glycyrrhiza glabra* L.), Ashvagandha (*Withania somnifera*), senna (*Cassia anguistifolia*, satwar (*Asparagus racemosus*) and kalmegh (*Andrographis paniculata*) was evaluated in vitro against root-knot nematode, *Meloidogyne javanica* and reniform nematode, *Rotylenchulus reniformis* water/methanolic extracts of these plants were prepared and tested against these nematodes at the concentrations of 1:5, 1:10, 1:20, 1:40 and 1:80. Observations on the larval/nematode mortality were recorded 48 hours of their exposure to the extracts. Results revealed that among the methanolic extracts tested *in vitro*, that of *Glycyrrhiza glabra* (mulhatti) and *Withania somnifera* (Ashvagandha) were highly effective against root-knot nematode (per cent larval mortality in case of G.glabra being 90.7 and 86.6 respectively at 1:5 and 1:10 dilutions while in case of *W. somnifera* being 96.1 and 96.0 and 83.7 at 1:5, 1:10 and 1:20 concentrations, respectively). Against *R. reniformis*, methanolic extracts of *Andrographis panniculata* was highly effective at 1:5 concentration (percent mortality being 84.0).

Demonstration of Management Strategies with Seed Treatment and Carbofuran in Chickpea Field against Root-Knot Nematodes

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Root-knot nematode *Meloidogyne incognita* and *M. javanica* adversely affect chickpea cultivation in field both way as qualitatively and quantitatively in light soils of middle Gujarat. To manage these nematodes problem, field study was conducted at Anand. Two treatments i.e. Monocrotophos 40 EC @ 0.1 % seed soaking for 6 hours and carbofuran @ 2 kg/ha soil application were tested with control. Total seven replications were tried in randomized block design using root-knot highly susceptible cultivar Dahod Yellow. Results obtained after pooled analyses of four years data revealed that grain yield of chickpea was increased 8.0 % due to the seed soaking treatment of monocrotophos 0.1 % and there by reduced root-knot disease upto 34.8 % incurring 7.4 % yield loss and carbofuran @ 2 kg/ha soil application increased 11.8 % grain yield by reducing 51.8 % root-knot disease incurring 27.3 % grain yield loss over control.

Plant Parasitic Nematodes associated with Polyhouse Carnation Crop in Northern Karnataka

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Cultivation of flower crops is concentrated in and around Bangalore and Belgaum cities in Karnataka. Belgaum has a polyhouse area of about 12.5 ha. meant mainly for carnation and gerbera. Information on plant parasitic nematodes associated with these polyhouse crops in northern Karnataka is practically not existing: Hence the study on carnation (*Dianthus caryophyllus*). A nematode random survey was carried out to fund out the pathogenic nematodes associated with the crop grown in twenty polyhouses in and around Belgaum. Symptoms observed on the poorly growing patches were plant stunting, knotted root system, coarse root system resulting in a reduced root volume and root lesions. Community analysis of associated PPN showed that spiral nematode, *Helicotylenchus dihystera* was the most prominent nematode present in polyhouses growing carnation in northern Karnataka. Reniform nematodes, lesion nematodes, root knot nematodes, dagger nematodes, other dorylaimid pathogens and Tylenchus-like nematodes though present, did not have high prominence values. *H. dihystera* caused severe stunting of the plants and delayed flowering under artificially inoculated conditions. These plants had extremely diminished root system. Final nematode population increased indicating that the nematode reproduced well on carnation. Staining of such root system showed the presence of *H. dihystera* in the root cortex. The present study constitutes a first report on the pathogenic nature of *H. dihystera* on carnation from India.

Comparative Efficacy of *Glomus fasciculatum* and *Pseudomonas fluorescens* on the Root-Knot in Tomato

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Application of *G. fasciculatum* @ 200 spores per g soil in nursery beds of tomato reduced the gall index to 2.33 from 2.66 as against 5.00 in control. Similar trend was also noticed at the harvest of the crop. The final root (5 g) and soil (200 cm^3) population was reduced by 41 per cent with 16 and 38 per cent increase in yield by the *G. fasciculatum*. *P. fluorescens* was also superior over control which resulted 36 and 24 per cent reduction in the nematode population and 8 and 3 per cent increase in yield during 2004 and 2005. Thus, *G. fasciculatum* was significantly superior in its efficacy against the nematode and yield of tomato over *P. fluorescens.*

Catalase and Superoxide Dismutase Isozymes of Indigenous *Steinernema* spp. (Nematoda: Steinernematidae)

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Isozymic profiles of catalase from infective juveniles of 5 indigenous *Steinernema* spp and *S. carpocapsae* (All strain), revealed distinct pattern of *Steinernema thermophilum* (IARI-EPN-1), by having 4 isozymic bands (Rf 0.06, 0.11, 0.19 and 0.3), the lower two bands being wider than the upper ones. *S. glaseri* (IARI-EPN-up1) and *S. riobrave* (IARI-EPN-gj1) exhibited only 2 bands, but of different Rf values, at 016 and 0.36 in the former and 0.13 and 0.19 in the latter. *S. carpocapsae*, *S. siamkayai* (IARI-EPN-ut1), and an undescribed species (IARI-EPN-mg1) exhibited similar banding pattern by having single band at Rf 0.19, being the widest in *Steinernema* sp (IARI-EPN-mg1), and it was also present in other *Steinernema* spp excepting *S. glaseri*. Isozymic profiles of superoxide dismutase also revealed 4 bands in *S. thermophilum* at Rf 0.42, 0.45, 0.52 and 0.64, the lower two bands being the unique for this species. *S. glaseri* possessed only one broad and intense band at Rf 0.42. *S. carpocapsae* revealed 3 isozymes, of which the first one at Rf 0.19 and third one at Rf 0.48 were unique to this species. *S. siamkayai*, strain IARI-EPN-mg1 and *S. riobrave* (IARI-EPN-gj-1) showed similar banding pattern, each having two isozymes at Rf 0.42 and 0.45. Isozymic profiles of catalase and superoxide dismutase from infective juveniles have been found to be useful for preliminary differentiation of some *Steinernema* species.

Population Dynamics of Nematodes in Different Cropping Systems in Semi arid Region

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Two years study undertaken on the population dynamics of four major nematodes viz., *Rotylenchulus reniformis*, *Pratylenchus* sp. *Helicotylenchus* spp and *Hoplolaimus indicus* associated with pigeon pea - wheat, maize – wheat, soyabean – wheat and sorghum – wheat under semi arid region (Indore) revealed that there was considerable variation in the increase and decline of the nematode population under the influence of the prevalent cropping systems in the region. The population of *R. reniformis* was maximum at the flowering stage of pigeon pea whereas, *Helicotylenchus* spp increased to its maximum in maize - wheat. The cropping systems comprising of both sorghum - wheat and soybean - wheat favoured maximum multiplication of *Pratylenchus* sp. However, the population of *Pratylenchus* sp was considerably favoured by wheat in sorgum - wheat cropping system.

Bioefficacy of Plant Growth Promoting Rhizobacteria against Root-Knot Nematode and Wilt Disease Complex in Betelvine

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Sixty five Plant Growth Promoting Rhizobacteria (PGPR) were isolated (50 *Pseudomonas* spp – Pfbv; 1 *Bacillus* spp – Bbv and 14 other rhizobacteria) from healthy betelvine rhizosphere in the districts *viz*., Tiruchirapalli, Namakkal, Coimbatore, Madurai, Erode and Thoothukudi. The isolates *viz*., Pfbv 22, Bbv 57 and Pf 1 were found to induce plant growth in rice as assessed by roll towel and pot culture studies and also effectively reduced the growth of *Phytophthora capsici in vitro.* The culture filtrates of Pfbv 22 showed significantly higher ovicidal and larvicidal action on *M. incognita* eggs and juveniles, respectively, followed by Bbv 57 and Pf 1. These isolates (in talc based formulations) were tested under field conditions at Karupathur (Tiruchirapalli district) against *M. incognita* and wilt pathogen in betelvine cv. Karpoori. The combination treatment Pfbv 22 + Bbv 57 recorded significantly higher growth parameters (plant height, number of laterals and leaf yield) and lower nematode and disease incidence. A confirmatory trial conducted at Kallapalli (Tiruchirapalli district) in betelvine cv. Vellakodi also revealed similar results. The treatment also enhanced the activity of defense enzymes responsible for induction of systemic resistance such as peroxidase, polyphenol oxidase and phenylalanine ammonia lyase.

Endophytic Bacteria Mediated Suppression of Nematodes and Panama Wilt Complex Disease in Banana

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In a random survey conducted in seven districts of Tamil Nadu, thirty nine non-pathogenic and beneficial endophytic bacteria (EPB) were isolated from healthy banana corms. The isolates were screened based on their growth promotion activity and antagonism against nematodes and panama wilt pathogen *in vitro.* Among the isolates, EPB 5, 22 and 31 were found more effective and were formulated in talc base. A pot culture study was conducted under glass house condition to assess the biocontrol potential of promising endophytic bacterial isolates against the nematodes of banana *viz*., root knot nematode, *Meloidogyne incognita*; lesion nematode, *Pratylenchus coffeae*; burrowing nematode, *Radopholus similis* and spiral nematode, *Helicotylenchus multicinctus* on tissue cultured banana cv. Robusta (*Musa* AAA). Significant increase in shoot height and weight, root length and weight, pseudostem girth and number of leaves, besides reduction in nematode population was observed in the combined treatment of EPB 5 + 31. Under field conditions, endophytic bacterial formulations were tested at the Horticultural Research Station, Thadiyankudisai in banana cv. Virupakshi (*Musa* AAB – Pome). The consortium of EPB 5 + 31 caused significant enhancement in plant growth parameters and yield along with reduction in nematode and panama wilt infestation. Another field trial conducted at SRS, Sirugamani also revealed similar results wherein significant reduction in nematode population and wilt incidence was noticed in the treatment EPB 5 + 31. The effectiveness of the biocontrol agents was comparable with Carbofuran and Carbendazim.

Combined Application of *Paecilomyces lilacinus* and *Pasteuria penetrans* for the Management of Root-Knot Nematode, *Meloidogyne incognita* in Banana

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The efficacy of *Paecilomyces lilacinus* (Thom.) Samson and *Pasteuria penetrans* (Thorne) Sayre and Starr, against the root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitw. on banana was evaluated and compared with the nematicide carbofuran. Application of *P. lilacinus* and *P. penetrans* in combined application or either organism with carbofuran reduced the nematode population and increased the plant growth. Maximum reduction of *M. incognita,* in terms of soil nematode population (78.4% over control), root-knot index (72.3% over control), number of eggmasses (73.3%) and number of eggs per eggmass (62.4% over control), was observed in the treatment of *P. lilacinus* and *P. penetrans.* Carbofuran alone was less effective. Treatment with *P. lilacinus* and *P. penetrans* recorded the maximum plant height (39.7 cm), root length (121.2 cm) and root weight (169.4 g) than other treatments.

Management of *Globodera rostochiensis* and *G. pallida* in potato by Antagonistic Crop, Mustard in Nilgiris

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Three field experiments were conducted at Wood House Farm and Anumapuram village in Nilgiris during the year 1997 - 98 to find out the influence of antagonism of mustard crop to potato cyst nematodes (PCN), *Globodera rostochiensis* and *G. pallida*. Mustard was tried as sole and as an inter crop at 1: 1, 1:2 and 1:3 plant ratios in reduction of initial population of PCN. Observations were taken on egg and larval content of cyst remaining in soil and infection of white females of PCN on potato roots. Experiment indicated that sole mustard crop in potato cyst nematode infested field reduced the cysts 0.8 times in terms of number of eggs and larvae than sole potato crop indicating severe inhibition of hatching. When it was grown as inter crop in potato field at 1:1 and 1:2 ratios, even though increased hatching was resulted, the infestation of PCN on potato root was significantly less due to non-attractiveness in presence of mustard seedlings. The tuber yield was also found enhanced by 36.8 percent at plant ratio of 1:1. Mustard intercrop when combined with application of Carbofuran 3 G @ 1 Kg a.i/ ha, reduced the infestation of PCN significantly by 30.5 per cent than untreated potato without inter crop.

Engineering Genetic Resistance against Root-Knot Nematode, *Meloidogyne incognita* in Tomato using an Antifungal Rice Chitinase Gene (*chi* 11)

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A rice chitinase gene (*chi*11) isolated from *Oryza sativa* was introduced into tomato (*Lycopersicon esculentum* Mill.) through Agrobacterium medicated transformation, using ubiquitin promoter. Transgenic plants demonstrated a high level of constitutive expression of *pchi*11. Kanamycin resistant T_1 plants (resulting from self-pollination of transgenic plants) were evaluated for their resistance against *Meloidogyne incognita* in greenhouse conditions. They demonstrated a significantly higher level of resistance to nematodes compared to the non-transgenic control plants, as measured by root knot index. The transgenic plants produced in the study were the first report of an antifungal rice chitinase gene (*chi*11) also confers resistance against root knot nematode, *M. incognita.*

Influence of *Pseudomonas fluorescens* on Histopathological Changes caused by *Meloidogyne arenaria* in Groundnut (*Arachis hypogaea* L.)

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The influence of *Pseudomonas fluorescens* on histopathological changes caused by *Meloidogyne arenaria* in groundnut (*Arachis hypogaea* L.) root revealed that, *M. arenaria* infection caused formation of typical multinucleate giant cell and associated abnormalities. In the case of *Pseudomonas fluorescens* (seed treatment of @10g/kg of seeds) treated groundnut roots, necrosis resisting the nematode infection appeared in the infection site following nematode penetration of roots. The nematode development in the root treated with *P. fluorescens* was greatly inhibited due to reduced number and poor development of giant cells. Repairing works of giant cells also found in *P. fluorescens* treated roots.

Occurrence of Reniform Nematode and Fusarium Wilt Complex of Chilli in Uttar Pradesh

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Chilli (*Capsicum annum* L.) is an important commercial vegetable crop extensively cultivated in different districts of Uttar Pradesh. Most of the Chilli crop plants were found to suffer from reniform nematode (*Rotylenchulus reniformis*) and *Fusarium solani* wilt complex. Affected crop field showed mild to severe wilting causing about 35 per cent losses. Affected crop plants showed yellowing, wilting, dwarfing, spreading nature and light brown to dark brown elongated patches appeared up to 3" – 4" height with collar girdling, axile buds and leaves were reduced later shed off, blossom and fruits malformed. Close examination of affected roots showed discolouration with the depletion of epidermis. Subepidermal, cortical and phloem lesions caused necrosis. Feeding in cortical tissues appeared with the presence of swollen reniform female larvae. Coilled male larvae were also present in the affected areas. All vascular and epidarmal tissues were found affected as secondary infection of *Fusarium solani* . The crop plants in case of mild infection caused 5 to 40 per cent infection and severely infected plants were observed to have 41 to 100 per cent infection. Both the pathogen simultaneously were found pathogenic under the test. *Meloidogyne* spp. *Rotylenchulus reniformis, Pratylenchus penetrans, Tylenchorhynchus brassicae* were dominated in the rhizospheric soil sample.

Parasitic Nematodes of Waikhong Fine Reserved Forest, Manipur and their Limiting Factors

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Waikhong Pine Reserved Forest consisting of an area of 5.10 sq. km. lies under the administrative control of Thoubal Forest Division. The said area comprises of the following hills-Leihaopokpi and Kala Lampak hills, Maning Ching, Tuheidaba Ching, Laichinglak and Utongyangbi Ching. Pine trees were artificially regenerated in this forest. Other common trees are *Quercus* sp., *Pasaria* sp., *Toona ciliata*, *Schima wallichii* etc. Altogether 30 plant parasitic nematodes were recorded from this area. The most commonly encountered nematodes were *Helicotylenchus erythrinae* followed by *Scutellonema sheri* and *Discocriconemella limitanea* respectively. The common limiting factors of these parasitic nematodes in the reserved forest were *Cladosporium cladosporoides* among the fungi and *Pseudomonas* sp. among the bacteria.

Biodiversity of Plant Parasitic Nematodes in Selected Districts of Andhra Pradesh

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A survey was carried out to prepare data base of plant parasitic nematode fauna in four districts of Andhra Pradesh (Anantapur, Chittoor, Kadapa and Nellore), A total of 211 soil and root samples were collected and these samples yielded 12 genera belonging to 7 families of 2 orders (Tylenchida and Dorylamida). Community analysis of 211 soil samples of different crops revealed the presences of *Meloidogyne incognita, M. graminicola, Rotylenchulus reniformis, Hirshmanniella oryzae, Radopholus similis, Pratylenchus* sp. *Helicotylenchus* sp. *Hoplolaimus* sp. *Criconemoides* sp. and *Scutellonema* sp. Forty one soil sample collected from banana, yielded two major plant parasitic nematode *viz*. *Xiphinema sp. and Helicotylenchus sp.* The spiral nematode recorded higher absolute frequency (36.59%), density (52.24%), and Prominence value (3.16%) followed by dagger nematode. In rice ecosystem of Nellore districts out of 36 samples analyzed the rice root nematode showed highest frequency (50.00%), density (80.53%) and Prominence value (5.69%) followed by *Scutellonema* sp., *Xiphinema* sp., *Helicotylenchus* sp., *Hoplolaimus* sp., and *Longidorus* sp. Analysis of hundred and thirty four soil samples of groundnut ecosystem from Anantapur and Chittoor districts yielded five species of nematodes *viz*., *Xiphinema* sp, *Rotylenchulus reniformis, Helicotylenchus* sp. and *Hoplolaimus* sp. Among these nematodes *Xiphinema* sp. showed highest frequency (58.04%) density (65.00%) and Prominence value (4.95%).

Parthenium; A New Weed Host for Reniform Nematode, *Rotylenchulus reniformis* (Linford and Oliveria, 1940) from Andhra Pradesh (India)

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A survey was carried out and 237 soils samples were collected from Agricultural Research Station (ARS) and farmers field in Kadiri, Anantapur Districts of Andhra Pradesh during the month of May, 2005. Soil and root samples of weed hosts were analyzed for nematode presence. The results revealed that majority of the soil samples contained male population of *R. reniformis* followed by *Xiphinema* sp and *Pratylenchus* sp. Among the 10 weed hosts only parthenium was infested with 30-40 females / plant by *R. reniformis* females with egg masses. The higher level of population may cause yield loss to groundnut crop, because groundnut also a good host for reniform nematode. Removal of weeds during non crop season is essential to avoid the population build up (alternate host) of nematodes. In conclusion, parthenium is not only a source of inoculum for Peanut Stem Necrosis Disease but also alternate host for reniform nematode. Eradication of parthenium may help to reduce the infestation of peanut stem necrosis disease as well as reniform nematode on groundnut.

Management of *Rotylenchulus reniformis* Linford and Oliveira in Cowpea by using Bio-control Agents

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It was revealed from a survey conducted all over the major vegetable growing tracts of West Bengal that the reniform nematode, *Rotylenchulus reniformis* Linford and Oliveira was the second most important plant pathogenic nematode next to the root-knot nematode in the state. Crop loss in cowpea due to this nematode in West Bengal has been recorded up to the tune of 10.74 per cent. To find out suitable management strategies against this nematode an experiment was conducted with a local popular variety of cowpea in a sick plot highly infested with *R.reniformis* at the Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. Total six treatments including an untreated control were laid out in a Randomized Complete Block design. All the treatments were applied as seed treatment and were replicated for four times. Total three bio-control agents *viz*., *Pseudomonas fluorescens, Trichoderma viride* and *Paecilomyces lilacinus* were applied separately each @ 2.5g/Kg of seeds. *Pseudomonas fluorescens* was also applied in combination with *Trichoderma viride* and *Paecilomyces lilacinus*. It was found that all the bio-control agents performed better than the untreated control. Sole application of *Pseudomonas fluorescens and Paecilomyces lilacinus* gave better result than *Trichoderma viride*. Due to the effect of treatments yield, fresh and dry weight of shoot and root, effective nodule number increased while egg mass index and final nematode population decreased. Highest yield and greatest reduction in final population of nematode were recorded for seed treatment with *Paecilomyces lilacinus* but highest nodulation was recorded in the plots treated with *Pseudomonas fluorescens.*

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Toxicity of Aqueous Extract of Edible Bamboo Shoot Products against Criconematids

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Study on the effect of aqueous extracts of edible bamboo shoot products viz. Usoi (fresh), Soibum (fermented) and Soidon (fermented) against *Discocriconemella aquatica* infesting *Parkia javanica* Merr. show that the edible bamboo shoot products exhibit nematicidal activity ranging 98.6-100 percent mortality at 24 hrs exposure period in 100% level of concentration. Test with further dilution at 5, 10, 20 & 50 percent concentration resulted with Soidon exerting 94.6 percent mortality of *D. aquatica* when exposed for 12 hrs in 50 percent concentration followed by 94.8 and 68.0 percent mortality with respect to Soibum and Usoi. The fermented products gave higher mortality rate to the nematodes population suggesting the possibility of using these bamboo shoot products as an ecofriendly and economical bionematicide.

Utilization of Medicinal Plants for the Management of Root-Knot and Reniform Nematodes Infesting some Vegetable Crops

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Root-dip treatment in the leaf extracts of *Cymbopogon flexuosus* and *Calendula officinalis* at different concentrations and dip durations brought about significant reduction in the poputation of plant parasitic nematodes such as *Meloidogyne incognita* and *Rotylenchulus reniformis* infestating tomato and chilli. The root-knot development and larval penetration of second stage juveniles of *M. incognita* were also inhibited, at varying extent depending upon the different concentrations and dip durations. Leaf extract of *C. flexuosus* caused more inhibition in root-knot development and nematode multiplication of reniform nematodes then that of *C.officinalis*. Plant growth improvement and reduction in multiplication of plant parasitic nematodes in dip treatments was observed in both the crops. The reduction in nematode population was increased with increasing concentrations of leaf extracts and dip durations.

Possible Utilization of Some Latex-Bearing Plants for the Management of Plant-Parasitic Nematodes Infesting Tomato and Eggplant

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Leaf extracts of latex bearing plants such as *Calotropis procera* and *Thevatia peruviana* were used as bare root-dip treatment for the management of plant parasitic nematodes. *Meloidogyne incognita*, *Rotylenchulus reniformis* and *Tylenchorhynchus brassicae* infesting tomato (*Lycopersicon esculantum*) and eggplant (*Solanum melongena*) plants. Significant reduction was observed in the root-knot devepment caused by *M. incognita* and nematodes multiplication of *R. reniformis* and *T. brassicae* on both the experimental plants. Larval penetration of second stage juveniles of *M. incognita* was also affected at different concentrations of leaf extracts and dip durations. Leaf extracts of *C. procera* caused relatively more inhibition in nematodes multiplication than that of *T. peruviana*. As a consequence of nematode control, plant growth improved and reduction in disease incidence increased with increasing the concentration of leaf extracts and dip durations.

Occurrence of Entomopathogenic Nematode (EPN) in Jhansi

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Rhabditid nematode species of Steinernematidae and Heterorhabditidae are pathogenic to a diverse group of hexapods particularly Lepidopterons and Coleopterans. They posses tremendous potential as bio-control agents. These nematodes can be recovered from naturally infested soils by baiting susceptible host insects. Hence, keeping in view the present studies were undertaken to isolate indigenous entomopathogenic nematodes. Surveys were conducted during 2004-05 at various locations in and around Jhansi. Sixty-seven soil samples were collected from different locations with varied microclimates, soil texture, moisture regime and crop/plant combinations by random sampling technique from the rhizosphere of the plants. Each of the soil samples was baited with laboratory reared greater wax moth larvae, *Galleria melonella.* Of sixty-seven samples two showed the presence of entomopathogenic nematodes (epn). In both the samples the, *G. melonella* larvae found to be infested by epn. The cadavers were removed and placed in white trap. After ten-twelve days the nematodes emerged out from the cadavers were koch-postulated for confirmation of the result. There was a positive response on test insect (*G. melonella*). The entomopathogenic nematodes were identified.

Biocontrol of Root Rot Disease Complex involving *Rotylenchulus reniformis* and *Rhizoctonia* sp. in Cotton

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A field experiment was conducted to determine the biocontrol efficacy of different biocontrol agents against disease complex caused due to *Rotylenchulus reniformis* and *Rhizoctonia* sp. in cotton. The treatments were seed treatment with *Trichoderma viride* @ 4g / kg seed, *Pseudomonas fluorescens* @ 20g / kg seed, *Paecilomyces lilacinus* @ 10 x 10^8 CFU/g, soil application of *Verticillium chlamydosporium* @ 10 x 10^8 CFU / g, *P. fluorescens* and *T. viride* @ 2.5 kg / ha and combination of seed treatment and soil application of *P. fluorescens* and *T. viride*. Among the treatments, combination of seed treatment and soil application of *P. fluorescens* recorded highest reduction of reniform nematode population to the tune of 63.05 per cent, highest kapas yield of 1.85kg/m2 and highest cost benefit ratio of 1:5.02 whereas highest reduction of root rot incidence was recorded in combination treatment as seed treatment and soil application of *T. viride* followed by combination treatment of *P. fluorescens.*

Efficacy of Neem and Pongamia Oil Formulations as Seed Dressing Materials against *Meloidogyne incognita* on Vegetables

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Emulsifiable concentrate formulations of neem oil viz., NO 60EC (A) and combination of neem and pongamia oil NOPO 60 EC (C) were tested as seed dressing materials to contain *Meloidogyne incognita* on tomato, brinjal and chilli in nursery. The formulations were treated at doses of 1 and 2ml / 10g seed. The experiment conducted for three seasons showed that all the three formulations were found significantly reduced root knot index and produced vigourous and healthier seedlings. Among the formulation of neem oil was found superior over other formulations in registering lowest root knot indices of 1.4, 1.4 and 1.2 respectively in tomato (PKM –1) brinjal (CO3) and Chilli (K1) as against 5.0 in the control. The same treatment has recorded 202.2, 126.6 and 138.8 per cent increase in shoot length over control respectively in tomato brinjal and chilli. No significant differences were noticed among the doses.

Bio-management of *Rotylenchulus reniformis* in Cowpea with *Trichoderma viride* and/or *Pseudomonas fluorescens*

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The biocontrol potential of *Pseudomonas fluorescens* and *Trichoderma viride* was evaluated as seed treatment for the management of *Rotylenchulus reniformis* infecting cowpea under field condition. The bioagents were mixed with the cowpea seeds either individually or in possible combinations @ 5 or 10g/kg of seeds. Treated seeds of cowpea were sown in plots each of 3x2. 5m net area with an average INP of reniform nematode as 267/200cc soil. Observation of final nematode population in soil as well as in root and yield/plot was recorded and compared with a chemical (carbosulfan ST @ 3% w/w) and an untreated check. Experimental results revealed that all the treatments reduced the final nematode population and increased the yield. Maximum decreases in nematode population (60%) as well as increase in yield (36%) were recorded in carbosulfan seed treatment. However, seed treatment with biocontrol agents either with *Trichoderma viride* @ 10g/kg seeds or when combined with *Pseudomonas fluorescens* @ 5g + 5g/kg seeds resulted significant reduction in nematode population (37% & 45%) while increasing the yield to the tune of 28 and 30% respectively. Moreover, the above two treatments were also at par with the carbosulfan treatment.

Management of Rice Root-Knot Nematode, *Meloidogyne graminicola* by Seed Soaking with Carbosulfan

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Root-knot nematode, *Meloidogyne graminicola* has been reported to be a serious pest of paddy and prevalent in all most all the districts of Orissa. Recently, its multiplication has crossed the damaging threshold limit in many of the coastal districts causing a serious threat to rice production and productivity. Considering its damaging potential, a demonstration trial was laid out at Sakhigopal of Puri district for economic management *M. graminicola* by using Carbosulfan as seed soaking. A heavily infected rice field with more than one larva /g soil was selected in this locality. The trial comprised of two treatments viz. T_1- treated (seed soaking with Carbosulfan 25 EC 0.1% for 12 hours) and T_2-Untreated. The main field was divided into two equal parts. In one part treated paddy seeds were sown and untreated seeds were put in other half of the main field. All other cultural operations were carried out equally in both the fields. Observations were recorded on final nematode population in soil, number of egg masses / 5g root and yield. Results of the trial indicated that seed soaking paddy seeds for 12 hours with Carbosulfan 0.1% could able to reduce the multiplication of root-knot nematodes in both soil and root by around 60%. There was an increase of 29.8% in yield of paddy. Finally a brief discussion was made involving other farmers of the locality and the importance of the root-knot nematode infecting rice was emphasized.

Integrated Approach for the Management of *Meloidogyne javanica* on Eggplant using Oil Cakes and Biocontrol Agents

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Investigations were carried out to evaluate the efficacy of biocontrol agents (*Paecilomyces lilacinus* and *Cladosporium oxysporum*) and / or oil cakes of castor, linseed, groundnut, mahua and neem in the management of root knot nematode, *Meloidogyne javanica* infecting eggplant under glasshouse conditions. All the treatments effectively suppressed the nematode population and kept the infection at significantly low level. Individual treatment of *P.lilacinus* was more effective than *C. oxysporum* in controlling *M. javanica,* whereas among oil cakes individual treatment of neem was more effective in the management of *M. javanica* followed by linseed cake, castor cake, groundnut cake and mahua cake. However, the efficacy of biocontrol agents increased in presence of oil cakes. The highest improvement in plant growth and best protection against *M. javanica* was obtained by the integration of *P. lilacinus* with groundnut cake followed by neem cake, linseed cake, castor cake and mahua cake. On the other hand the integration of *C. oxysporum* with neem cake followed by groundnut cake, linseed cake, castor cake and mahua cake gave best results in managing *M. javanica* on eggplant.

Integrated Approach for Managing Root-Knot Nematode (*Meloidogyne incognita*) in Pointed Gourd (*Trichosanthes dioica* Roxb.)

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A field experiment was conducted with eight treatments (plot size: 3.6 x 3m^2) comprising of Vine dipping (VD) + farm yard manure (at 20t/ha), vermicompost (at 2t/ha), *Trichoderma viridae* (at10g/pit), *Paecilomyces lilacinus* ((at 10g/pit in), neem cake (at 500 kg/ha) and carbofuran 3G (at 1 kg a.i./ha), vine dipping in monocrotophos (at 100ppm for 6 hours) alone and untreated control at Seed farm, Kalyani of Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India for managing root knot nematode (*Meloidogyne incognita*) in pointed gourd cultivar '*Dhepa*'. Experimental results revealed that Vine dipping (VD) + *Trichoderma viridae* at 10 g/pit (in two split dose) was superior to all the treatments and this was followed by VD + Vermicompost at 2t/ha, Vine dipping (VD) with monocrotophos36SL at 1000ppm for 6hrs + decomposed organic matter at 20t/ha. Adoption of vine dipping in monocrotophos 36SL at 1000ppm followed by soil inoculation of *T. viridae* at 10g per pit once at planting and second dose at 40 days after planting reduced root galling caused by *M. incognita* and gave fruit yield which was almost double of the untreated plots. No effect of nematode attack on fruit size (diameter, length) and weight was observed.

A Novel Process to Produce Commercial Biopesticides for the Management of Nematodes

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A novel process to produce biopesticides has been invented. The process involved the production of stock culture of biocontrol fungi and bacteria on sawdust - soil - 5% molasses mixture (15:1:1) and immobilization (carrier) of the microorganisms in the flyash - soil - 5% molasses mixture (5:1:1). The composition of the biopesticides was 1 part stock culture and 15 parts carrier. Using the process, three biopesticides, Biowilt-X (*Trichoderma harzianum*), Bionem-X (*Pochonia chlamydosporia*) and Biocomp-X (*Pseudomonas fluorescens*) were produced to control soil borne plant nematodes e.g., root-knot nematode (*Meloidogyne* spp.). Patent for the process and products has been filed (Ref. 1621/DEL/2005). The three biopesticides developed are superior to their contemporaries available in the market with regard to CFU load and cost. Shelf life of the biopesticides was tested at five temperature regimes i.e., 5 °C, 10 °C, 15 °C, 25 °C and ambient (March onwards) for 32 weeks. The biocontrol agents not only remained viable but also multiplied during the storage. At ambient temperature, The CFU count in the biopesticides was 10^{8-9} CFUs of *T. harzianum* and *P. chlamydosporia* and 10^{10-13} CFUs of *P. fluorescens*/g formulation. The formulations were packed in commercial polypacks of 200, 500 and 1000 grams. The manufacturing cost of 200 g biopesticide packet hardly comes Rs. 10 and can be sold for less than Rs 50.

Characterization and Pot Evaluation of Soil Isolates of *Aspergillus niger* for Effectiveness against Root-Knot of Egg Plant

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The fungus, *Aspergillus niger* was isolated from forty different crop fields and pure cultured on potato dextrose agar. The isolates were characterized for production of ammonia, hydrogen cyanide, hydrogen sulphide, indole acetic acid, siderophores, phosphate solubilization and nematode suppression *in-vitro*. Four soil isolates of *A. niger* viz., AnC_2, AnR_3, AnM_3 and AnL_3 were selected on the basis of above characters to evaluate the effectiveness against *Meloidogyne incognita* on egg plant, *Solanum melongena* cv. Pusa Kranti in 25 cm clay pots filled with 2 kg sterilized soil. The isolates were applied in soil (1 g/kg soil) and on roots (bare root dip treatment). The pot soil was preinoculated with 2000 freshly hatched juveniles of *M. incognita* per kg soil. The cultivar Pusa Kranti was found susceptible to the nematode infection and exhibited significant decrease in the plant growth (16%) and flowering (18%) of egg plant. Application of *A. niger* isolates checked the galling and reproduction of the nematode and improved the growth variables ($P \leq 0.05$). The isolate AnC_2 was found highly effective checking the galling by 26% and improved the dry matter production and flowering by 17% and 27%, respectively. The isolates also acted as plant growth promoter and significantly increased the dry matter production of egg plant . The isolates AnC_2 was found best for both the situations.

Wilt Disease Complex on Pigeonpea and its Management with some Biopesticides in a Field Plot

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Three biopesticides namely Biowilt-X (*T. harzianum*), Bionem-X (*P. chlamydsopdoria)* and Biocomp-X (*P. fluorescens*) were tested against the disease complex caused by *Fusarium udum* and *Meloidogyne incognita* concomitantly on pigeonpea. The study was conducted in microplots (2x4 m) and the biopesticides were applied to the seeds of pigeonpea cv. UPAS-120 @ 2 g/kg seed along with the commerical rhizobium and cost benefit ratio was calculated. Inoculations with the pathogens were done at a rate of 5 g *F. udum* colonized seeds and/or 2000 freshly hatched juveniles of *M. incognita* per kg soil. The pathogen inoculations resulted to 4.8 q/ha (wilt) and 2.6 q/ha (root-knot) reduced yield of pigeonpea valuing Rs. 8460 and 4680/ha. The disease complex decreased the yield by 7.3 q/ha valuing Rs. 13140/ha. Seed treatment with Biowilt-X and Bionem-X effectively checked the severity of fusarial wilt and root-knot disease of pigeonpea and gave a profit of Rs. 8140/ha and Rs. 4180/ha, respectively. The Biocomp-X was found effective against mono and multipathogenic diseases and enhanced the yield that valued to Rs. 6100/ha.

Field Trial of Some Biopesticides for the Management of Root-Knot, Wilt and Disease Complex on Chickpea

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A field trial was undertaken to evaluate the effectiveness of the biopesticides namely, Biowilt-X (*Trichoderma harzianum*), Bionem-X (*Pochonia chlamydsopdoria)* and Biocomp-X (*Pseudomonas fluorescens*) against root-knot (*Meloidogyne incognita*), wilt (*Fusarium oxysporum* f. sp. *ciceris*) and wilt disease complex caused by *Fusarium oxysporum* f. sp. *ciceris* + *Meloidogyne incognita* on chickpea. The biopesticides were applied to the seeds of chickpea cv. BG 256 @ 5 g/kg seed along with the commerical rhizobium under field conditions and cost benefit ratio was calculated. Soil of the microplot was inoculated with fungus *Fusarium oxysporum* f. sp. *ciceris* colonized seeds (1.5 g/kg soil) and/or *M. incognita* (2000 J_2/kg soil). The wilt and root-knot nematode disease reduced the yield of chickpea by 5.2 q/ha and 3.3 q/ha valuing Rs. 8320 and Rs. 5280/ha. The wilt disease complex of chickpea reduced the yield (8.5 q/ha) valuing Rs. 13600/ha. Treatment with Biocomp-X and Bionem-X satisfactorily managed the wilt and root knot disease giving a profit of Rs. 6220/ha against wilt and Rs. 3180/ha against root knot. Treatment with Biocomp -X significantly controlled wilt, root knot and disease complex of chickpea with a profit of Rs. 4300/ha. Treatment of Biocomp-X induced greater increase in nodulation on the plants inoculated with the pathogenic fungi and/or nematode.

Wilt Disease Complex of Gladiolus and its Management

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Wilt disease complex is an important disease of gladiolus and causes tremendous damage with regard to spike quality. The disease is a result of concomitant infection with *Fusarium oxysporum* f. sp. *gladioli* and *Meloidogyne incognita.* The study involved inoculations with the fungus (2 g/kg soil) and nematode (2000 J_2 /kg soil) and application of *Trichoderma virens, Pseudomonas fluorescens* and nemacur + carbendazim in 25 cm clay pots filled with 2 kg sterilized soil. The five cultivars of gladiolus (*Gladiolus pittacinus*) tested were found susceptible to the wilt fungus and root knot nematode, concomitant inoculation was more damaging. Application of *T. virens* or carbendazim decreased the corm rot and yellows leading to corresponding increase in plant growth and flowering variables of gladiolus cultivars ($P \leq 0.05$). Nemacur or *P. fluorescens* treatment checked the galling caused by *M. incognita.* The disease complex was, however, effectively controlled with the application of carbendazim-nemacur mixture or *P. fluorescens.*

Effects of Soil Isolates of *Aspergillus niger* for Effectiveness against Root-Knot - Root Rot Disease Complex of Egg Plant

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A pot study was conducted to examine effectiveness of some selected soil isolates of *Aspergillus niger.* Numerous isolates of *A. niger* were collected from different crop fields and pure cultured on potato dextrose agar. The isolates were characterized for production of ammonia, hydrogen cyanide, hydrogen sulphide, indole acetic acid, siderophores, phosphate solubilization and antagonism against the root-rot fungus (*Rhizoctonia solani*), root-knot nematode (*Meloidogyne incognita*) *in-vitro*. Four soil isolates of *A. niger* viz., AnC_2, AnR_3, AnM_4 and AnT_3 were selected on the basis of above characters to evaluate the effectiveness against root knot - root rot disease complex caused by *M. incognita* and *R. solani* concomitantly on egg plant, *Solanum melongena* cv. Pusa Kranti. The trial was under taken in 25 cm clay pots which were filled with 2 kg sterilized soil (field soil + compost, 3:1). The isolates were applied in soil (1 g/kg soil) and on roots (bare root dip treatment). Before seedling planting the soil in pots was inoculated concomitantly with 2000 freshly hatched juveniles of *M. incognita* and 2 g sorghum seed colonized by *R. solani* (2 g/kg soil). The cultivar Pusa Kranti was found highly susceptible to the disease complex and exhibited significant decrease in the plant growth (39%) and flowering (44%). Application of *A. niger* isolates checked the galling and reproduction of the nematode, decreased the root rot index and improved the growth variables ($P \leq 0.05$). The isolate AnC_2 was found highly effective checking the root rot and galling by 39% and 27%, respectively and also improved the dry matter production and flowering by 29% and 33%, respectively.

Effect of Different Inoculations with *Meloidogyne incognita* on *Fusarium udum* Resistant Pigeonpea Accessions

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A pot culture study was conducted to find out the effect of sequential and concomitant inoculations with root-knot nematode *Meloidogyne incognita* and *Fusarium udum* on the wilt resistant accessions of pigeonpea viz., DPPA 85-11, DPPA 85-5, DPPA 85-14, Banda Palera and Sujata. An initial population of 1000 freshly hatched juveniles of *M. incognita* and 4.0 g culture of *F. udum* per kg of soil was used. The seedling mortality induced by *F. udum* in all five accessions was highest where *M. incognita* was inoculated simultaneously with *F. udum* followed by *M. incognita* prior to *F. udum* and *F. udum* prior to *M. incognita.* The mortality was highest (67%) in DPPA 85-14 followed by DPPA 85-11 (58%), DPPA 85-5, Sujata (50% each) and Banda Palera (33%). Final population of the nematode was highest in *M. incognita* alone followed by *M. incognita* + *F. udum* simultaneously, *M. incognita* prior to *F. udum* and *F. udum* prior to *M. incognita.* Shoot height, number of branches and fresh and dry weight of shoot and root of pigeonpea accessions were significantly lower in *M. incognita* + *F. udum* simultaneously followed by *M. incognita* prior to *F. udum, F. udum* prior to *M. incognita*, nematode alone and fungus alone as compared to check.

Management Approaches of Tuberose Foliar Nematode, *Aphelenchoides besseyi* in West Bengal, India

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A field experiment was conducted at Horticultural Research Station of Bidhan Chandra Krishi Viswavidyalaya, Mondouri, Nadia with six treatment combinations under field conditions to test the efficacy of the treatments for managing foliar nematode (*Aphelenchoides besseyi*) problem in tuberose. T_1= Pre-soaking of bulbs in plain water for overnight + three sprayings with monocrotophos 36SL at 500ppm at 15 days interval (DI) repeated the same spraying in second year from March onwards, T_2= Dipping of bulbs in Neem Seed Kernel Extract (NSKE) 5% for 6 hours + 1st spray with cartap hydrochloride 50SP at 700 ppm and 2nd and 3rd spray with NSKE 10,000 ppm at 2 ml/litre of water at 15 DI (repeated the same as above), T_3= Pre-soaking of bulbs in plain water for overnight + Dipping of bulbs in benomyl 50 WP at 3 gm/litre of water for 15 min. + 1st spray with benomyl at 1 gm/litre of water, 2nd and 3rd spray with NSKE 10,000 ppm at 2ml/litre of water at 15 DI (repeated the same as above), T_4= Soil application of carbofuran 3G at 1 kg a.i./ha + three sprays with NSKE 10,000 ppm at 2 ml/litre of water at 15 DI (repeated the same as above), T_5= Farmers' practice (untreated bulbs + spraying with carbosulfan 25EC at 750 ppm as and when required and T_6= Untreated control plot. The adoption of different management approaches significantly suppressed nematode attack on tuberose as compared to untreated plots. The nematodes infestation varied from 13% to 38% in the treated plots and 32% to 50% and 32% to 62% in farmers' practice and untreated plots, respectively. The maximum infestation (62%), nematode population (mean population density 3,387/flower stalk) and lowest yield (mean 323 flower stalks/plot-1.5 x 1.8 m^2) was recorded in the untreated plots. The Percent Disease Index (PDI) value was varied from 12% to 33% in the treated plots whereas in untreated plot as well as in farmers practice, it was ranging from 27% to 56%. Among the treatments, T_1 was the best treatment which was followed by T_2, T_3, T_4 and T_5.

Benificial Nematodes of Manipur

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An investigation carried out in Manipur for Beneficial Nematodes in 2004 recorded 43 Predatory Nematodes, 10 Entomophilic Nematodes and 25 Saprophytic Nematodes. Of the Predatory Nematodes 40 belongs to the order Mononchida Jairajpuri, 1969 and 3 belongs to the order Dorylaimida Pearse, 1942. Predominent ones among the Entomophilic Nematodes were *Steinernema* sp. *Heterorhabditis* sp. and Mermathids. Saprophytic Nematodes recorded during the study belong to the order Rhabditida (Oerley, 1880) Chitwood, 1933

Recent Advances in the Management of Nematodes on the Nursery Seedlings of the Vegetable Crops

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Of late, there have been significant changes in the production of the nursery seedlings of the vegetable crops. Many farmers are using the seedlings grown in coco-peat in trays. Surveys conducted in Karnataka state indicated the association of root-knot nematode - *Meloidogyne incognita* and reniform nematode - *Rotylenchulus reniformis* with nursery seedlings of tomato, capsicum and egg plant. Hence standardized methods for the production of nematode free seedlings of tomato, capsicum and egg plant under the department of bio-technology programme, using botanicals and bio-pesticides. One method is growing seedlings in the coco-peat treated with 1 kg of each of *Pseudomonas fluorescens* (10^9 cfu/g) and *Paecilomyces lilacinus* (10^7 cfu/g) /ton. Another method is to treat the coco-peat with 1 kg of each of *P. fluorescens* and *P. lilacinus* + 10 kg of neem (de-oiled) cake + 5 kg of carbofuran/ton of coco-peat. By growing the seedlings of above mentioned vegetable crops, it was possible to get 60 - 67% of the seedlings with out nematode infestation in the first method and 92 - 96% in the second method. Studies on the rhizospheric competency and compatibility among the components used, revealed that *P. fluorescens* or neem cake or carbofuran did not affect the colonization of the *P. lilacinus* on the roots of seedlings to tomato, capsicum and egg plant. Further, there was an additive effect in bringing down the nematode infestation. Our studies indicated that the treatment of coco-peat in the ways mentioned above increase the growth of seedling roots significantly when compared to that of the seedlings grown in un-treated coco-peat. These findings indicate that it is essential to treat the coco-peat for obtaining nematode free nursery seedlings of the crops.

Biochemical Characterisation of Some Indian populations of Root-Knot Nematodes, *Meloidogyne* spp.

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Ten root-knot nematode (*Meloidogyne* spp.) populations collected from various states of India identified upto species level based on morphological and morphometric data, were subjected to Poly acrylamide micro-slab gel electrophoresis for resolving the b-esterase isozymic profiles of mature females in order to characterise and differentiate the populations biochemically. The isozyme profile exhibited presence of typical three bands having Rf values (0.45, 0.5 and 0.54) for Delhi-I and Tamilnadu populations but slightly higher Rf values (0.49, 0.57 and 0.61) for Hisar population confirmed these three populations as *Meloidgyne javanica*. Himachal Pradesh population possessing one isozyme band having Rf value 0.49 was identified as *M. hapla*. Besides Delhi-II, Orissa and Maharastra populations showed one isozyme band each of Rf value 0.47, which was also typical pattern of *Meloidogyne incognita.* Maharastra population of *M. incognita* exhibited some variation from the typical pattern by having one additional band of Rf value 0.51 and hence found variant population of *M. incognita*. Jammu & Kashmir, Keral and U.P populations identified morphologically as *M. arenaria*, *M. piperi* n.sp. and *M. jepsonae* n.sp. respectively could not be differentiated from each other on the basis of b-esterase profiles.

Management of Nematodes on Carnations

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Root-knot nematode - *Meloidogyne incognita* is an important factor affecting the commercial cultivation of carnations (*Caryophyllus dianthus*) in poly-houses. Surveys also indicated the wide spread nature of this nematode in most of the carnation growing areas in Southern India. In this communication results obtained in the management of *M. incognita* on carnations are given.

Application of 50 g of each of organic formulations of *Pseudomonas fluorescens* (10^9 cfu/g) + *Pochonia chlamydosporia* (10^7 cfu/g) + carbofuran per sq. meter of the bed at the interval of 4 months was found to reduce the nematode infestation by 72%. This treatment was also found to increase the yield the flowers by 21%. Application of either carbofuran or the bio-pesticides separately did not reduce the nematodes significantly. Studies on the rhizospheric competency of these bio-pesticides revealed that *P. fluorescence* or carbofuran did not affect the colonization of the *P. chlamydosporia* on the carnations roots. Application of carbofuran also along with these bio-pesticides did not affect the their colonization on the roots of carnations. These studies on the compatibility of these bio-pesticides and chemicals will help in the successful use of the bio-pesticides in integrated management of nematodes on the horticultural crops.

Seasonal Population Behaviour of Phytonematodes associated with Pulse-based Cropping System

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Routine collection of soil samples from the rhizosphere of four pulse based cropping systems such as Ricebean-Maize-Fallow, Ricebean-Groundnut-Fallow, Cowpea-Groundnut-Fallow and Blackgram-Mustard-Fallow from July'2000 to June'2001 from central farm, OUAT, Bhubaneswar at monthly interval followed by wet screening of soil samples and counting of phytonematode populations of each crop throughout the year revealed that *Rotylenchulus reniformis, Hoplolaimus indicus, Helicotylenchus dihystera* and *Caloosia exilis* were consistently associated with each cropping system over the year but exhibited varying population fluctuation in different cropping systems. Total phytonematode populations exhibited two peaks in the year; one in September and the other in March in Ricebean-Maize-Fallow and Blackgram-Mustard-Fallow systems, but only one peak during September in Rice bean-Groundnut-Fallow and Cowpea-Groundnut-Fallow systems. The trend of seasonal oscillation had no linear correlation between mean monthly temperature as well as rainfall. While perceiving the effect of different cropping systems on the reproductive growth of phytonematodes, Ricebean-Maize-Fallow system supported highest growth factor (2.95) followed by Blackgram-Mustard-Fallow (2.01) with the lowest reproductive factor (0.71) in Cowpea-Groundnut-Fallow cropping system.

Virulence of *Heterorhabditida indica* to the Grubs of Lucerne Weevil, *Hypera postica* (Coleoptera; Curculionidae)

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Entomopathogenic nematodes of the genera *Steinernema* and *Heterorhabditis* are highly pathogenic to several Coleopteran and Lepidopteron insects. In an attempt to establish the virulence of *Heterorhabditis indica* against lucerne weevil, *Hypera postica* – a burning problem in Lucerne (*Medicago sativa)* cultivation, laboratory bioassay tests were carried out during 2004-05 at Indian Grassland and Fodder Research Institute, Jhansi. It has been noticed that there was a positive correlation between nematode concentration and *Hypera postica* mortality. At 24 hrs after inoculation there was 93.20 per cent mortality of *H. postica* at a dose of 160 Ijs, 86.40 per cent mortality at a dose of 80 Ijs, while 59.60%, 33.00% and 6.60% mortality of lucerne grubs have been observed at a dose of 40,20 and 10 Ijs respectively. After 48 hrs of inoculation there was 100%, 93.20%, 66.40%, 46.20% and 13.20% mortality have been recorded. At 72 hrs after inoculation there was 100% mortality at a dose of 80 Ijs while 79.60%, 73.00% and 19.8% mortality was noticed at a concentration of 40, 20 and 10 Ijs. Our findings indicate that *Heterorhabditis indica* is effective enough for the management of *Hypera postica* and will suppress lucerne grub populations effectively under natural ecosystems.

Role of Entomopathogenic Nematodes in Management of Cotton Insect-Pests

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The Entomopathogenic nematodes (EPN) have generated a great deal of interest in recent years because of their recognition as bio-control component in Integrated Pest Management (IPM) of cotton. These nematodes have found a great utility in IPM system because of their locomotory capabilities and ability to cause quick death of the insect pests Entomopathogenic nematode, *Heterorhabditis indica* isolated from cotton ecosystem (Rainfed, Irrigated) were evaluated against *Helicoverpa armigera* (American bollworm) and other cotton insect pests. It was found effective against all larval instars of American bollworm (*H.armigera*), Spodoptera (*Spodoptera litura*), leaf roller (*Sylepta derrogata*), pink boll worm (*Pectinophora gossypiella*) and spotted boll worm (*Earias spp.*) with significant larval mortality. Ten infective juveniles (IJ) of *H. indica* per larva of *H. armigera* was found to be the effective dose. A new susbstratum has been standardized for mass production of virulent infective juveneiles for field application. Feasibility of mass producing *H.indica* inoculum on cottage industry scale using field collected lepidopteran larvae for field application has also been worked out. The spray schedule of *H.indica* infective juveniles has been worked out in delivery system of cotton IPM. Field application of *H.indica* at 2-3 billion/ ha was found to reduce the American bollworm (*H.armigera*) population by 60%. The field results have indicated that use of entomopathogenic nematodes have great potential for sustainable management of cotton insect- pests, particularly the American bollworm causing heavy field losses and damaging environment due to use of harmful pesticides.

Avoidable Losses in Cotton due to Plant Parasitic Nematodes

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Cotton, the most important natural fiber, occupies pride of place in economy of our country. Plant parasitic nematodes have recently been recognised as capable of inflicting loss on cotton crop. Loss due to plant parasitic nematodes is hard to discern in cotton as it is a hardy perennial crop and losses get camouflaged. During mapping of Central Institute for Cotton Research, Nagpur fields spread over about 258 acres, reniform nematode, *Rotylenchulus reniformis* was found as the most dominant and frequent nematode species. Population of reniform nematode ranged between 80-380 nematodes /250 cc soil at sowing. At mid season, the population ranged between 425- 560 nematodes/250 cc soil. On termination of crop which also concides with onset of winter, the population was found to dip to 10-30 nematodes/250 cc soil. A pot experiment was set up to simulate field conditions and estimate threshold level of damage. At population level of 138 nematodes /250 cc soil, root weight was found to be reduced by 30% while reduction in shoot weight was 11%. To assess field losses in cotton due to plant parasitic nematodes, field experiment was conducted for two consecutive seasons. Carbofuran 3G was applied at 1 Kg a.i./ha. The treatments were Imidochloprid seed treatment for control of sucking pests, nematicide treatment, Imidochloprid + nematicide treatment and control. Results indicate that in nematicide treated plots, there was increase of 8-10% seed cotton yield over control indicating avoidable losses due to plant parasitic nematodes in cotton.

Integrated Management of Root-knot (*Meloidogyne incognita*) Nematode in Tuberose

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In recent times the tuberose (*Polyanthes tuberosa* L.) is gaining importance as an important commercial flowering crop for the small and marginal farmers of the Athgarh block of Cuttack district, Orissa. During the survey of the block a field where tomato crop previously grown was found heavily infested with root-knot nematode having population density 2.2 J_2 /g soil. So a field trial was laid out in the same plot to determine the influence of inoculum of *Meloidogyne incognita*(Kofoid and White) Chitwood on the growth and flower yield of the crop. Various organic amendments i.e. oil cakes of neem, mahua, karanj, and vermicompost each @ 250 g/ m^2 ; carbofuran 3G @ 1.5 kg a.i./ha and bio-agent *Trichoderma viride* @ 2 x 10^8 spores / g soil were applied individually as well as in different combinations for the management of root-knot nematode. There was appreciable increase in plant growth and flower yield from the plot amended with organic amendments over untreated control. Maximum flower yield (25.27%) as a result of increased plant growth (50.12%) and reduced nematode population (60.75%) was observed with treatment combinations of vermicompost, neem oilcake, and carbofuran over the control.

Influence of 28-homobrassinolide on Development of Second-stage Juveniles of *Meloidogyne incognita* (Kofoid & White) Chitwood

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Brassinosteroids represent a group of ubiquitous occurring phytohormones with a high plant growth-promoting and anti-stress activity. In animal system too, they seem to regulate their growth and development. Since animal system reportedly respond to these steroidal compounds, it was envisaged to study their effect on nematode system. 28-Homobrassinolide (HBl), a brassinosteroid tested in earlier *in vitro* studies showed that they enhance the egg hatch of a root-knot nematode, *Meloidogyne incognita*. Some more studies were conducted by giving indirect treatments of 28-homobrassinolide to the second-stage juveniles of *M. incognita*. The seeds, roots and leaves of tomato cv. Pusa Ruby were treated with five different concentrations (ranging from 10^{-10}M to 10^{-5}M) of HBl and then untreated second stage juveniles (@ 10 J_2/ gm soil) were released on treated plants. Seed and root-dip treatment of tomato plants with HBl resulted into more number of galls and greater egg mass number as compared to control plants whereas foliar spray had not much effect on nematode development.

Efficacy of Single and Combined Application of *Pasteuria penetrans* and *Paecilomyces lilacinus* for the Management of *Meloidogyne incognita* on Chilli

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Effect of single or concomitant application of *Pasteuria penetrans* (50 and 100g *P. penetrans* infested soil/kg soil) and *Paecilomyces lilacinus* (4 and 6g *P.lilacinus* culture/kg soil) on various growth characters of chilli and management of *Meloidogyne incognita* was studied under pot conditions. Application of both the bioagents either alone or in combination was observed to mitigate the adverse effect of nematode on plant growth to varying degrees. Combined application with higher dose of *P. penetrans* and *P. lilacinus* was found to completely reverse the adverse effect of nematode on fresh and dry weights of shoot and it was at par with that of the absolute check treatment. Similarly, higher dose of *P. penetrans* along with the either dose of *P. lilacinus* was observed to enhance the dry weight of root and it was similar to that of the check treatment. In general combined application with higher dose of both the bioagents caused 75 and 77% increase in fresh weights of shoot and root and 139 and 84% increase in dry weights of shoot and root. Both the bioagents alone or together were also observed to cause drastic reduction in average number of galls/root system and final population of *M. incognita*. Individual application with both the doses of *P. penetrans* or higher dose of *P. lilacinus* or combined application with lower doses of *P. penetrans* and *P. lilacinus* were observed to be at par with each other with respect to the reduction in gall numbers and nematode population. In general, combined application with higher dose of application of *P. penetrans* and *P. lilacinus* resulted in the maximum reduction of 62.6% in gall numbers and 82.2% in nematode population over the nematode check.

Mass Production and Formulations of *Paecilomyces Lilacinus*

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Nematophagus fungus *Paecilomyces lilacinus* was mass produced in different media and formulated in various carriers. The media tested were Potato dextrose broth (PDB) , Richard's medium, 10% molasses and semi selective medium. The highest fungal biomass production was observed in Richard's and semi selective medium 17.82g and 15.56 respectively. The least production was observed in PDB 10.5g. In semi selective medium spore load of *P. lilacinus* was the highest (32.8×10^6) and the lowest spore load was observed in PDB (10.3×10^6). In various formulations tested *viz.* talc, fly ash, rice hull ash and vermiculite, *P. lilacinus* was found viable for 120 days in talc and fly ash followed by rice hull ash and vermiculite (90 and 75days respectively).

Nemic Bio-diversity in Seven Districts of Southern Gujarat, India

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Systematic survey of seven districts (Surat, Bharuch, Navsari, Vadodara, Narmada, Valsad and Ananad) of Gujarat, India was conducted to know the biodiversity of plant parasitic and beneficial nematodes. Altogether 48 soil samples were collected from the rhizosphere of different vegetable, cereal, oil-seed and fruit crops. Analysis of different crops revealed the occurrence of 18 genera of beneficial and 17 of plant parasitic nematodes. Among the beneficial nematodes, mycetophagous nematode *Aphelenchus avenae* was the most frequently occurring with its relative frequency (30.5%) followed by *cephalobus persegnis* (14.7%); *Leptonchus capitatus* (9.4); *Alaimus* sp.; *Ditylenchus triformis* and *D. myceliophagous* (5.2), and the minimum being for rhabditids and *Nygolaimus* sp. (1.05%). Among the plant parasitic nematodes *Helicotylenchus indicus* and *H. retusus* were the most frequently occurring with high relative frequency (29.74%), followed by *Pratylenchus zeae* and *P. brachyurus* (14.86%), *Tylenchorhynchus bravilineatus, T. nudus* and *T. mashhoodi* (9.46%), *Rotylenchulus reniformis* (8.11%); *Hoplolaimus indicus* and tylenchidae (6.75%), *Meloidogyne incognita, M. javanica* and *Scutellonema unum* (5.40%), and the least being for 10 other tylenchid species. Among the beneficial nematodes, *Ditylenchus* spp. was recorded to have maximum relative density, (38.1%); followed by *A. composticola* (7.0%); *Cephalobus persegnis* (4.2%), *Plectus* sp. (4.0%), *Alaimus* sp. (3.7%), free living dorylaims (3.7%), *A. avenae* (3.4%), araeolaimids (2.4%), enoplids (1.6%) and *Mylonchulus* sp. (1.2%). In case of plant parasitic nematodes, maximum relative density was recorded for *Tylenchus* and allied genera (6.2%),followed by *Meloidogyne* spp. (5.6%); *Tylenchorhynchus* spp. (5.0%); *Pratylenchus* spp. (4.22%); *Helicotylenchus* spp and *R. reniformis* (3.9%) and *Hoplolaimus indicus* (1.2 %). In Valsad, despite having very high nematode density, the proportion of beneficial nematodes was only 15% and the remaining 85% were plant parasites. In other 6 districts, the percentage of beneficial nematodes varied from 47 to 69%, minimum being in Narmada and the maximum in Vadodra.

Effect of *Pasteuria penetrans* on the Life Cycle of *Meloidogyne incognita*

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Pasteuria penetrans, a biological control agent for root knot nematode has great potential for development as a bio nematicide. Hence a study was conducted to determine the effect of *P. penetrans* on the life cycle of *Meloidogyne incognita.* The J_2 of *M. incognita* was exposed to endospore of *P. penetrans* and inoculated in tomato plants under glass house conditions at 28˚C. Penetration and development of J_2 was observed at 2 days interval from the day of inoculation. The infected nematodes showed a 2 days delay in penetration when compared to control. Total life cycle of the infected nematode was extended to 6 days when compared to healthy nematodes.

Efficacy of Certain Rhizosphere Fungi against Root-Knot Nematode (*Meloidogyne incognita*) and *Rhizoctonia solani* in Tomato Crop

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Plant diseases of economic crops alone causes 13-20% annual loss in production representing 50×10^9 US $. It is recorded that 90% of the 2000 major diseases of the 31 principal crops in U.S. are caused by soil borne pathogens. In the absence of exact estimates in India it can be easily assumed that > 50% crop losses are due to soil inhabiting microorganisms. Cultivation of tomato, a unique vegetable crop, spread all over India occupying ~ 2lakh ha and contribute 7.7% of total production of vegetables. Tomato too suffers with great losses mainly due to soil borne pathogens *Rhizoctonia solani* causing damping off, root rot etc and *Meloidogyne incognita* causing root rot diseases. Both of the pathogens occupy the same niche and thus the loss to crops becomes many times more than two individuals separately. In nature mono pathogenic condition is very rare and co inhabitant non-pathogenic rhizosphere fungi might influence this disease complex. Present studies were conducted under invitro conditions to find out the effect of certain rhizosphere and rhizoplane and four genera were selected, namely *Epicoccum purpurascens*, *Penicillium vermiculatum, Trichothecium roseum* and *Trichoderma viridae*. Fungi were inoculated both at germination and transplantation stages, since tomato is a transplanted crop, separately and in different combinations with *R. solani* and *M. incognita*. Results indicated that the reduction in growth was the maximum in plants treated with *R. solani* and or *M. incognita* (41.6%) while it was 36.17% in case of *R solani* alone and 32.07% for nematode alone. Reduction in growth was lesser for all the four fungi but *T. roseum* proved most effective. The growth of *T. roseum* treated plant was more than the control in different treatments. Its inoculation in combination with nematode showed 13.27% increase while increase was 1.89% with *R. solani* followed by *P. vermiculatum*, *Trichoderma viridae* and *Epicoccum purpurascens*. However in tri pathogenic conditions *Epicoccum purpurascens* was most effective. *T. roseum* also influenced the multiplication of nematode adversely. Findings indicate that shifting the balance of the rhizosphere mycoflora in the favour of these genera can be helpful in regulating the disease complex.

Reaction of Some Varieties of Greengram to Root-Knot Nematode, *Meloidogyne incognita* Race-2

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The root-knot nematode *Meloidogyne incognita* is considered as one of the major nematode pest of greengram. Since resistant varieties of crops are better suited than application of chemicals and other methods for management of plant parasitic nematodes, an attempt was made to screen some varieties of greengram against root-knot nematode, *M. incognita* race-2. A total of twenty five varieties were procured from Pulse Research Station, Nayagarh and centre for Pulse Research, Berhampur. None of the tested varieties was resistant to root-knot nematode. Four varieties viz., Ganga 10, ML-131, TARM-1, Pusa 9531 exhibited moderately resistant reaction. Others were categorized as either susceptible or highly susceptible.

Establishment of Organogenetic Root Cultures for Aseptic Establishment of Root-Knot Nematode, *Meloidogyne incognita*

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Excised root segments, hypocotyl region, zone of transition between root and shoot and cotyledonary leaves of tomato were cultured on MS medium containing 1-3 mg/l of IAA, 2,4-D, kinetin and BAP. The response of different explant tissues to growth hormones varied with the type and concentration of the hormone. In general, IAA was observed to induce root formation while 2,4-D to induce callus formation from various explant tissues. BAP and Kinetin were found to give poor to good response for callusing except for zone of transition between root and shoot where besides callus few roots were also produced. The roots produced from different tissues showed normal branching. All the root cultures established on IAA supplemented medium when inoculated with surface sterilized larvae of *M. incognita* were observed to be susceptible to the nematode. Most of the nematode infection on such roots was recorded on emerging lateral roots near the growing tips. The nematode took 27 days to complete life cycle and average number of eggs/egg mass was recorded to be 268 eggs. This was almost similar to the nematode that was cultured on aseptic root cultures established from seedlings on growth hormone free medium. Two life cycles of the nematode could be easily competed on these roots. The results of the study suggest that pure populations of *M. incognita* can be successfully reared on organogenetic root cultures established on growth hormone supplemented medium.

Reaction of *Bt* Cotton and Popular Cotton Varieties to *Rotylenchulus Reniformis*

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The Bt cotton MECH 184 and non *Bt* cotton varieties were studied for their effect on reniform nematode. The study showed that there was significant reduction in reniform nematode population *Rotylenchulus reniformis,* masculisation and subsequent increase in biomass of cotton . Development of nematode and egg production is also delayed in Bt cotton than in non Bt cotton. Further, root leacheats from Bt and non Bt cotton plants were taken to study the effect of toxin on nematode through contact nematicidal assay, influence on egg hatching, penetration of juveniles in cotton root under glasshouse conditions. The results showed no mortality of juveniles in contact nematicidal assay. However 3-4 days delay in hatching and subsequent development to J_3 stage in Bt cotton. Penetration study showed normal penetration of J_4 in roots of both in Bt and non Bt cotton.

Field Efficacy of Entomopathogenic Nematode, *Steinernema riobrave* and their Toxins against Root-Knot Nematodes, *Meloidogyne* Spp. on Okra

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ICAR Adhoc Project on EPN, Department of Nematology,
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Entomopathogenic nematodes (EPNs) are innovative bioagents for the plant protection scientists in India having effective suppression of insects as well as phyto-nematodes in soil. To prove EPN antagonistic to PPN phenomenon, an experiment was carried out in RKN (mix population) sick field having INP > 1 nema / g soil in *kharif* 2004. All the treatments viz. IJS of *S. riobrave* isolates M & A @ 1 lakh / 6.75 m^2; treatment of undiluted exotoxin factor of symbiotic bacteria *Xenorhabdus* isolated from A & M as seed soaking and soil application (@2%); along with treated checks, Tricho X-P (10 kg/ha, *P.lilacinus* and *Trichoderma*) and carbofuran (1 kg/ha) and a untreated control, thus total nine treatments were applied in furrows before seeding of the crop. The okra GOH1 seeds were sown at 45 cm x 15 cm distance by dibbling in 3.0 m x 2.25 m plots. Observations on plant height at 45 days of seeding and root-knot index (RKI) at harvest were recorded. Okra fruit yield was also recorded at regular intervals throughout the season.

Interaction effect of EPN, *S. riobrave* M & A and their respective symbiont bacterial toxin against RKN indicated that both EPNs and *Xenorhabdus* toxins (undiluted) have suppressive effects against RKNs on okra. Lowest RKI (2.09) was recorded in toxin of *Xenorhabdus* (*Sr* M) seed soaking treatment which was at par with fungal bioagent (2.66); IJs of *Sr* A (3.14) and carbofuran (3.23) treatments compared to untreated control (4.92). Seed soaking treatment of toxins found better then soil application of toxins and *S. riobrave* IJs application. Significantly higher okra yield was recorded in carbofuran treatment, which was statistically at par with Tricho X-P treatment followed by EPN *Sr* M & A and other treatments.

Meloidogyne javanica on *Withania somnifera* (L.) from Rajasthan- A New Report

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Withania somnifera (L.), Ashwagandha due to its medicinal importance is cultivated in Ajmer, Jaipur, Jodhpur, Tonk and Kota distts. etc. on the demand of various industries. The samples procured from disease area (Jaipur Distt.), were full of galls on roots. The females of the nematode were analysed in detail on the bases of shape, size and perinneal pattern basis. All these characters were matching and super imposable to *Meloidogyne javanica.* The *M. javanica* on Ashwangadha is the first report from Rajasthan State.

Effect of Soil Types on *Meloidogyne-Fusarium* Complex in Rajasthan State.

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Rajasthan is biggest state of India in area with diverse climatic and edaphic conditions. Pulses account for their vital role in nutritional security and soil ameliorative properties and thus form integral part of sustainable agriculture. Chickpea (*Cicer arietinum* L.) belonging to family Fabaceae is the major pulse crop grown in the state due to favorable environmental conditions. Survey of the fields in Rajasthan showed heavily infected fields due to effect of nematode-fungal complex. Root-knot nematode *Meloidogyne incognita* and wilt fungus *Fusarium oxysporum* when present together are highly destructive resulting in a wilt disease complex. The severity of disease also varies according to the climatic and edaphic conditions. When pot experiments were conducted with five types of soil collected from different districts of Rajasthan *viz* Churu, Jhunjhunu, Tonk and Jaipur keeping all other conditions similar except for the soil type, variable results were obtained. Plant growth parameters *viz* is shoot-root height and weight was observed to be minimum in case of sandy-loam soil infested with both the pathogens added with dosage of, 1000 J2/pot+15g *Fusarium* multified on sorghum grains and simultaneously followed by other types while clayey showed least galling and wilting. It was also observed that plant in control showed maximum growth in all five types of the soils than those with nematode alone and wilt fungus alone treatment.

Management of *Meloidogyne incognita* using Biocontrol Agents on *Coleus forskohlii*

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Pot culture experiments were conducted under glasshouse condition for the evaluation of biocontrol agents for the management of *Meloidogyne incognita* on *Coleus forskohlii*. Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha showed increased plant growth and reduced root knot nematode population both in soil and root. *Trichoderma viride* @ 2.5 kg/ha (soil application) also recorded increased plant growth and reduced nematode population compared to control followed by *P. fluorescens.*

Nematode-Fungal Disease Complex involving *Meloidogyne incognita* and *Macrophomina phaseolina* on *Coleus forskohlii* Briq.

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A Glasshouse experiment was carried out under glasshouse condition at Nematology laboratory of Tamil Nadu Agricultural University, Coimbatore, to study the interaction of *Meloidogyne incognita* and *Macrophomina phaseolina* on *Coleus forskohlii*. The treatment includes nematode and fungus alone, nematode followed by fungus, fungus followed by nematode, simultaneous inoculation of nematode and fungus and an uninoculated control. The nematode multiplication was adversely affected when fungus was inoculated prior to nematode compared to other treatments. Simultaneous inoculation of nematode and fungus as well as nematode followed by fungus 15 days later caused 100 percent root rot disease and significant reduction in plant growth compared to the inoculation of fungus alone or fungus inoculation prior to nematode.

Integrated Management of Root-Knot Nematodes in Tomato Nursery through Botanical Plant Materials

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Root-knot disease is a serious problem in vegetables in light soils of middle Gujarat. To overcome the pesticide residues in vegetables through integration of non chemical methods, the present experiment was undertaken. Soil solarization with 25 μ LLDPE for 15 days in hot summer integrated with Ipomea, congress grass, fresh neem leaves and aak along with Sebufos and Carbofuran as a treated check were tried in Randomized block design with three replication in nursery beds. Highly root-knot susceptible variety Junagadh ruby was seeded @ 20 kg/ha. Three years pooled data indicated significant differences for all the attributes under study except for germination count indicating that there is no any toxic effect of various botanical plant materials or nematicide on tomato seed germination. In general soil solarization was more effective than no solarization. As regards incorporation of green materials, all green materials significantly increased plant growth and development and there by significantly increased no. of transplantable and total seedlings and there by significantly reduced root-knot index as compared to control and chemical application of sebufos and carbofuran. Thus integration of soil solarization with LLDPE transparent film of 25 μ for 15 days and different botanical plant materials viz. Ipomea, Parthenium, Azadiracta and Aak were found most effective for management of root-knot nematodes in tomato nursery and there by production of transplantable seedlings was higher.

Genetic Variability in Thermo-Tolerance and Virulence among Isolates of Entomopathogenic Nematodes from Sugarcane Ecosystems

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Identification and utilization of native isolates of entomopathogenic nematodes (EPN) with superior traits will enhance their success rate in biological control of insect pests. Temperature tolerance and virulence are two important traits that determine the success for EPN under field conditions. In this study, we assessed the variability in temperature tolerance and virulence among eight isolates of *Steinernema* and four isolates of *Heterorhabditis* collected from different sugarcane ecosystems of India for identifying isolates with superior traits. Temperature tolerance was quantified by assessing percent survival of infective juveniles exposed to 40^{o}C for varying periods. Among *Steinernema* isolates, KSF and H3 showed higher temperature tolerance (with 68.9 and 61.3% survival of infective juveniles, respectively at 40^{o}C after 24h). Among *Heterorhabditis* isolates, H2 and SBI3 showed higher temperature tolerance (with 85.0 and 61.8 % survival of infective juveniles, respectively at 40^{o}C after 8 h). In general, *Steinernema* isolates exhibited relatively higher temperature tolerance compared to the *Heterorhabditis* isolates and none of the *Heterorhabditis* isolates survived beyond 8 h at 40^{o}C. Variability in virulence among *Steinernema* and *Heterorhabditis* isolates was evaluated using one-on-one and five-on-one sand well bioassays, respectively with *Galleria mellonella* larvae as host. *Steinernema* isolates DD136 and S230 recorded higher insect mortality (93.7 and 87.5%, respectively) compared to other isolates. Among *Heterorhabditis* isolates, SBI3 and CH2 recorded higher insect mortality (95.8 and 91.3%, respectively) compared to other isolates.

In vitro Production of Native Isolates of *Heterorhabditis indica* and *Steinernema siamkayai*

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Native strains of entomopathogenic nematodes *viz., Heterorhabditis indica* (TNAU-EPN-Hi3) isolated from Kodaikanal and *Steinernema siamkayai* (TNAU-EPN-St3) from Walayar (Coimbatore district) regions of Tamil Nadu were mass produced *in vitro* using ten various media containing materials of plant origin. Among the different media tested, maximum multiplication of *H. indica* (689 X 10^3) was recorded in Wouts medium containing soy flour and corn oil followed by medium VI containing bengalgram flour and gingelly oil (607.4 x 10^3). Maximum multiplication of *S. siamkayai* (501 X 10^3) was observed in Wouts medium followed by medium V containing bengalgram flour and groundnut oil (388 x 10^3).

Effect of Plant Growth Promoting Rhizobacteria on lesion nematode *Pratylenchus zeae* and Plant Growth in Sugarcane

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Plant growth promoting rhizobacteria (PGPR) have been shown to suppress root-knot nematodes in certain crops. In this study, we have evaluated the suppressive potential of six plant growth promoting bacterial species against lesion nematode *Pratylenchus zeae.* Nematode suppressive potential of bacterial isolates was quantified in a laboratory experiment by assessing mortality of nematodes exposed to bacterial culture filtrates at different dilutions (ranging from 4-16 times). Nematode mortality in bacterial culture filtrates ranged from 21.2 to 94.6%. Nematode mortality increased with the increase in the concentration of culture filtrate. Maximum nematode mortality of 94.6% was recorded in culture filtrate of *Pseudomonas aeruginosa* followed by *P. fluorescens* and *Gluconacetobacter diazotrophicus* at all the dilutions tested. In another experiment, effect of the six PGPR on multiplication of the lesion nematode and growth of sugarcane plants was assessed in pot-culture. When inoculated simultaneously with lesion nematode, four out of six PGPR isolates, *viz*. *Azospirillum brasilense, Gluconacetobacter diazotrophicus, Pseudomonas aeruginosa* and *Bacillus megatherium* recorded significantly higher root and shoot dry weight and total plant biomass compared to the plants inoculated with nematode alone and control plants that were inoculated with neither nematodes nor PGPR. Maximum plant biomass in the presence of lesion nematode was recorded in plants inoculated with *A. brasilense.* Maximum reduction in nematode multiplication (49.7 and 47.5%, respectively) was recorded in plants inoculated with *P. aeruginosa* and *P. fluorescens,* which were on par with each other.

Biochemical and Physiological Alterations Induced in Greengram by *Trichoderma viride* against Root Knot Nematode *Meloidogyne incognita*

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Systemic resistance induced in greengram (*Vigna radiata*) by treatment with *Trichoderma viride* was evaluated against root knot nematode *Meloidogyne incognita*. Higher activity of defense enzymes *viz.,* peroxidase (PO), polyphenoloxidase (PPO), phenylalanine ammonialyase and chitinase was observed in *T. viride* treated plants compared to untreated plants. Isoform analysis revealed unique PO and PPO isoforms induced in *T. viride* treated plants. Accumulation of proline, lignin and phenols was the highest in combined application of *T. viride* as seed treatment (4g/kg seed) and soil application (10 g/ m^2). Chlorophyll pigmentation was lower in nematode infected plants due to reduced availability of nutrients and water. Application of *T. viride* increased the chlorophyll content significantly thereby altering the physiology in favour of the host plant against the nematode attack.

Management of Wilt Disease Syndrome of *Meloidogyne incognita*, *Ralstonia solanacearum* and *Fusarium solani* in Eggplant (*Solanum melongena* L.)

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The eggplant is most important vegetable crop grown throughout the year in Konkan region of Maharashtra State, especially in districts of Thane and Raigad.Wilt of eggplant is one of the major constraints in it's production. In a roving survey conducted in Raigad and Thane districts of Maharashtra during *Rabi* 2004-05, the incidence of wilt ranged from 15.85 and 29.15 per cent in Raigad district and 14.49 and 33.12 per cent in Thane district. Overall, 25 per cent wilted samples revealed association of fungus, bacterium, root- knot nematode, *Meloidogyne incognita* which were isolated, purified and their pathogenicity was proved on seedlings. The pathogens were taxonomically identified as *Fusarium solani* (Mart.) Sacc., *Ralstonia solanacearum* E. F. smith and *Meloidogyne incognita* (Kofoid and White). The effect of different inoculum levels of fungus at 1, 2, 4 and 8 g/kg of soil and bacterium at 1, 2, 4 and 8 ml/kg of soil on eggplant was studied. In case of *F. solani,* 2 g/kg of soil was sublethal level and it was 2 ml/kg of soil in case of *R. solanacearum,* which were used for interaction studies. Among various fungicides tested, 0.1% Bavistin was most effective recording 90 per cent inhibition of *F. solani*, while Copper oxychloride and Strepromycin sulphate were the most effective against *R. solanacearum.* In biological control experiment, *Trichoderma harzianum* (P), *T. harzianum* (Jc) and *T. viride* were most effective against both the pathogens.*In vitro* screening of plant extracts revealed that, Karanj (*Pongamia pinnata*) leaf extract (10%) was most effective against *F. solani* causing 76.66per cent inhibition in growth over control, while Neem (*Azadirachta indica*)(10%) also was effective against *R. solanacearum.* Field trial conducted for management of wilt complex revealed that, treatments comprising drenching with Copper oxychloride @ 3g/l of water, soil application of Bio-Sanjeevani [containing *Trichoderma viride, Pseudomonas fluroscence* and *Paecilomyces lilanicus* (1:1:1)] a product of Nirmal Organo Biotech. Pvt. Ltd., Pachora, @ 10 kg/ha and drenching with Bleaching powder @ 3g/l of water were effective, while treatments comprising soil application of Bio-Sanjeevani @ 10 kg/ha and soil application of *Paecilomyces lilanicus* @ 2.5 kg/ha were effective in reducing root-knot nematode infestation. The highest yield (20.07 t/ha) was obtained due to drenching with COC @ 3g/l of water followed by 19.8 t/ha. by soil application of Bio-Sanjeevani applied @ 10 kg/ha as also eggplant yield of 18.92 t/ha.was achieved due to drenching with 0.3% Bleaching powder as against only the yield of 5.90 t/ha. in untreated plot.

Amongst 18 varieties screened under natural conditions, Arka Nidhi, IHR-7, SM-66,BB-68, Arka Keshav, BB-60-C, BB-13-1 and Arka Neelkanth were found resistant to bacterial wilt, while Brinjal 71-19, Arka Nidhi, IHR-7, BDIRT, JC-2, BB-13-1, Arka Neelkanth were observed field resistant to root-knot nematode, *Meloidogyne incognita.* These varieties can be grown in endemic pockets of Konkan region accompanied with most effective treatments of fungicides, bactericides and bioagents revealed here.

Studies on the Effect of "Fallowing" on the Population of *Hirschmanniella Gracilis* (De Man, 1880) Luc And Goodey, 1963 (Tylenchida: Nematoda) in Paddy Fields at North 24-Parganas, West Bengal, India

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During December, 1990 – November, 1992, three plots measuring 10m X 10m at Rautara village, north 24-Parganas, West Bengal were selected to study the effect of three types of fallowing – short, very short and prolonged fallowing on *Hirschmanniella gracilis* and non – phytonematodes and to compare the effect of prolonged fallowing with that of short and very short period of fallowing. It was observed that the rate of decline of population of *H./ gracilis* during the fallow period of 1992 was more than that of the fallow period of 1991. This happened probably due to the non-availability of host plants in the field of prolonged fallowing which was kept under long period fallowing. Thus, it was also observed that the plots with short and very short period of fallowing had no significant effect on the nematode population. The study also revealed that the changes of population of non-phytonematodes of the three plots under different fallow periods was insignificant. This was probably due to the fact that the presence or absence of host plants did not affect the population of non-phytonematodes as they are indifferent to the presence of host plants, while *Hirschmanniella gracilis* is host dependent. While studying; the effect of fallowing on population of *Hirschmanniella gracilis,* some important factors viz., soil temperature and soil moisture were taken into consideration and accordingly, correlation of such factors with population of *Hirschmanniella gracilis* and non-phytonematodes has also been established.

Efficacy of Bare Root Dip Treatments of Various Neem Based Pesticides and *Trichoderma s*pp. against *Meloidogyne incognita* and Plant Status of Tomato

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Neem formulations viz., Econeem, Nimbecidine, Neem Gold, Neem Azal and Neem seed kernel extract (NSKE) and two fungal bioagents viz., *Trichoderma viride and T. harzianum* were tried as bare root dip treatments for their effect on *Meloidogyne incognita* (Kofoid and White) Chitwood and growth parameters of *Lycopersicon esculentum* Mill. Plant growth characteristics improved significantly in all the treatments as compared to untreated control. Plant roots dipped in fungus formulations attained overall better status as compared to those dipped in neem based formulations. Among neem-based formulations, the best plant status was acquired by the plants, roots of which were dipped in NSKE followed by Econeem. Interestingly, variation in period of dipping exposure had a non-significant role and in general, similar plant status was attained whether dipping were given for two, four, six or eight hours. Minimum population of *Meloidogyne incognita* was found in the plants whose roots were dipped in *Trichoderma harzianum* followed by those dipped in *T. viride,* NSKE, neem Gold and Econeem, all of which showed significantly uniform nematode population. Significantly reduced root galling as compared to control were achieved in all the test formulations with maximum reduction in *T. harzianum, T. viride,* NSKE, and Econeem dipped plants. As root dips are most economical and highly effective against *M incognita,* dip treatments could be preferred over drenching, which may not be economically viable due to high cost and low persistence.

Evaluation of Neem Based Pesticides against *Meloidogyne incognita* (Kofoid and White) Chitwood in *Lycopersicon esculentum* Mill.

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Studies on effect of neem based formulations viz., Econeem, Nimbecidine, Neem Gold, Neem Azal and Neem seed kernel extract (NSKE) each at concentrations of 0.25, 0.5 and 1.0 per cent on plant status of *Lycopersicon esculentum* Mill. revealed that all the test formulations improved the plant growth characteristics like aerial height, shoot weight, root length, root weight etc., as compared to control by checking nematode multiplication significantly. This eventually led to reduced galling of roots in all the treated plants as compared to untreated control plants. The best plant growth parameters were attained in NSKE treated plants closely followed by Econeem. However, at lower concentration of 0.25 per cent, NSKE showed more efficacy against *Meloidogyne incognita* than Econeem, Nimbecidine, Neem Gold and Neem Azal, all of which had uniform but significantly reduced effect. Interestingly at high concentration of one per cent, all the test formulations were equally effective. Correlation studies revealed that root galling was directly proportional to nematode count and vice versa. Econeem and NSKE were effective at lower concentration of 0.5 per cent. Among various concentrations tested one per cent concentration was adjudged to be most effective and no phytotoxicity with any of the formulations was observed up to this level.

Three New Mononchid Species under the Genera *Mylonchulus, Iotonchus* and *Margaronchulus* (Mononchida:Nematoda), with Unusual Extra Genetalia in *Iotonchus*, from South 24 Parganas, West Bengal, India

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Three new species under the genera *Mylonchulus* Cobb, 1916, *Iotonchus* Cobb, 1916 and *Margaronchulus* Andrassy, 1972 are described and illustrated. Length of *Mylonchulus wasimi* n. sp. is 1.50 – 1.85 mm. No male, but eight female representatives are found under this proposed new species. Body cuticle thin, oesophago-intestinal junction nontuberculate, ovary amphidelphic, vulval papillae present, tail short, dorsally bent, digitate. Iotonchus carticaudatus n. sp. with large body (female : L = 2.83 – 2.90 mm; male : L = 2.29 – 3.16 mm). Twelve female and seven male specimens are found of this species. Buccal capsule broad, dorsal tooth situated 14.1 µm from the base of buccal cavity in both females and males; no sub ventral teeth, oesophago-intestinal junction tuberculate, vulval papillae present in female, tail elongate type, caudal glands prominent. One female specimen of Iotonchus carticudatus n. sp. having two sets of fused gonads showing bivulvarity. *Margaronchulus istvani* n. sp., small bodied nematode, length of which is 0.77 - 0.84 mm, male absent but two female specimens are found. Body curved, buccal cavity with a large dorsal tooth but lack of having any subventral tooth, oesophago-intestinal junction non tuberculate with a distinct cardia, ovary mono prodelphic, tail short with blunt tail tip, caudal glands and spinneret absent.

Suitability of Two Cyst Nematode Resistant Potato Hybrids for Cultivation in Nilgiri Hills

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The potato cyst nematodes (*Globodera pallida* and *G. rostochiensis*) and the late blight disease (*Phytophthora infestans)* are the two major plant protection problems of Nilgiri hills, where potato can be grown throughout the year in this area and cause severe yield losses. The cyst nematodes are widely spread in all the major potato growing localities of Nilgiri hills while the late blight disease appear with the onset of monsoons every year in an epidemic form. In view of the above, and considering the need for developing suitable potato varieties having combined resistance to both these problems several advance generation hybrids were developed. The selections were subjected to rigorous testing under glass house conditions for their reaction to both species of potato cyst nematodes and those selections, allowing less than five females per root ball, compared to more than 250 females in susceptible variety Kufri Jyoti were retained. The selections were simultaneously tested for late blight disease under field conditions with the standard scoring of 1-9 scale of increasing resistance. Among 21 short listed hybrids, two hybrids namely, OS/93-D-204 and OS/94-L-956 performed better for their total yield, tuber characters in the preliminary and confirmatory yield trials in addition to having desirable level of resistance to both potato cyst nematodes and the late blight.During 2003 and 2004, these two selections were introduced in adaptive research trials (ART) at Nanjanad and Theetukkal in the farmer's holdings where potato cyst nematodes and late blight disease are the major potato problems. The advance hybrids were planted in four replications at both localities in randomized plots along with standard potato cultivars. Assessing the initial and final populations, the nematode build up was monitored while the late blight incidence was recorded at periodical intervals on all the test varieties. During both these years minimum plant protection that is practiced by the respective farmers were adopted to compare these hybrids with standard potato cultivars Kufri Giriraj and Kufri Jyoti. At harvest the total yields and the marketable yields were ascertained. The results showed that on an average, the hybrids OS/93-D-204 and OS/94-L-956 recorded a late blight score of 6 to 6.3 (4.6 in Kufri Giriraj and 1.0 in Kufri Jyoti) and were superior in total tuber yield averaging 312- 315 q/ha respectively, compared to 189 q/ha in Kufri Giriraj and 131 q in Kufri Jyoti. Similarly the marketable yields were also higher (279- 283 q/ha) in these hybrids. The cumulative nematode reduction in terms of cysts and eggs and larvae per cysts these test varieties ranged from 0.15 to 0.20 as against 12.75 in Kufri Jyoti. These studies indicated that the above two advance hybrids would be suitable as future potato varieties for Nilgiris region as they are adapted to local conditions and posse's desirable level of resistance to both species of potato cyst nematodes and field resistance to the late blight disease.

Nursery Management of Rice Root-Knot Nematode, *Meloidogyne graminicola*

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Field experiments were conducted during Samba season (July-November 2002-03) with rice varieties ADT 38 and Co.47 for the nursery management of rice root knot nematode *Meloidogyne graminicola.* The study revealed that soil application of carbofuran 3 G at 1 kg a.i./ha was found to be effective against the nematode and its effect was comparable with the use of bioagent *Pseudomonas fluorescens*@2.5kg/ha as nursery soil application in minimizing the incidence of rice root knot nematode and to improve the growth of seedlings.

Fluctuation of Nematode Population associated with Banana Plantation in Paschim Medinipur District, West Bengal, India.

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Monthly population fluctuation of four plant parasitic nematodes, *Rotylenchulus reniformis, Tylenchorhynchus coffeae, Helicotylenchus crenacauda* and *Hoplolaimus indicus* associated with banana plantation (*Musa Paradisiaca* cv 'Kanthali'), was studied in Paschim Medinipur District, West Bengal, India, during March 2004 to February 2005. Findings show strong seasonal population fluctuation. All the four species reach their peak in August, then declines till January. In March a second but smaller peak is seen, followed by a decline till June. Thus some sort of a bimodal population fluctuation has been observed in all the cases. In the present work an attempt has been made to study the correlation between the population of that four species with soil temperature, moisture, pH, and organic carbon content of the soil. Temperature, moisture and organic carbon show positive correlation with the population. But pH shows negative correlation that is the population of the species is inversely proportional with the degree of acidity of the soil.

Studies on the *Meloidogyne incognita-Rhizoctonia solani* Complex on the Disease Development and Yield of Tomato cv. K-25

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Studies were carried out under pot conditions to determine the effect of *Meloidogyne incognita* (@ 4000 J2/4 kg soil) and *Rhizoctonia solani* (@ 10 g mycelium/4 kg soil) on the disease development and yield of tomato cv. K-25. Results indicated that *M. incognita* was more capable in reducing the plant growth and fruit yield of tomato than *R. solani*. Maximum reduction in plant growth and yield was found in plants inoculated with both the pathogens simultaneously followed by nematode seven days prior to fungus, fungus seven days prior to nematode, nematode alone and fungus alone respectively. However, highest reproduction rate and root-knot index were observed in plants inoculated with the nematode alone followed by nematode prior to fungus, nematode-fungus simultaneously and fungus prior to nematode respectively. Results also revealed that the root colonization by fungus was significantly high in the presence of *M. incognita* as compared with the *R. solani* alone.

Occurrence and Control of Plant Parasitic Nematodes infesting Saffron (*Crocus Sativus* L.) in Kashmir

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Saffron (*Crocus sativus* L.) the legendary crop of the state of Jammu and Kashmir, is generally infested with several plant-parasitic nematodes namely *Pratylenchus*, *Helicotylenchus*, *Xiphinema*, *Tylenchorhynchus* and *Aphelenchoides* spp. The results of a trial conducted at Saffron Research Station, Konibal, Pampore revealed that the soil treatments viz., cartap 4% @ 1000 g.a.i.ha^{-1}, chlorpyriphos 10G @ 1000 g.a.i.ha^{-1}, carbofuran 3% @ 1200 g.a.i.ha^{-1}, fipronil 0.3% @ 70 g.a.i.ha^{-1} and fenvalerate 0.4% @ 120 g.a.i.ha^{-1} not only reduced the nematodes population significantly but also increased the percentage of corm germination as well as flower production as compared with that of check. However, population counts of the nematodes receiving the soil treatments did not differ significantly from each other, yet the order of efficacy of the treatments was found in the order of chlorpyriphos > carbofuran > fenvalerate > cartap > fipronil.

Demonstration of Management Strateges with Seed Treatment and Carbofuran in Chickpea Field against Root-Knot Nematodes

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Root-knot nematode *Meloidogyne incognita* and *M. javanica* adversely affect chickpea cultivation in field both way as qualitatively and quantitatively in light soils of middle Gujarat. To manage these nematodes problem, field study was conducted at Anand. Two treatments i.e. Monocrotophos 40 EC @ 0.1 % seed soaking for 6 hours and carbofuran @ 2 kg/ha soil application were tested with control. Total seven replications were tried in randomized block design using root-knot highly susceptible cultivar Dahod Yellow. Results obtained after pooled analyses of four years data revealed that grain yield of chickpea was increased 8.0 % due to the seed soaking treatment of monocrotophos 0.1 % and there by reduced root-knot disease upto 34.8 % incurring 7.4 % yield loss and carbofuran @ 2 kg/ha soil application increased 11.8 % grain yield by reducing 51.8 % root-knot disease incurring 27.3 % grain yield loss over control.

Effect of Karanj cake and VAM fungus on growth of tomato infected with root-knot nematode and wilt fungus

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An experiment was carried out to study the effect of Karanj cake (*Pongamia glabra)* and VAM fungus (*Glomus fasciculatum*) on growth of tomato infected with root-knot nematode (*Meloidogyne incognita*) and wilt fungus (*Fusarium oxysporum* f. sp. *lycopersici*). Reduction in disease severity with enhancement in plant growth was recorded in the plants treated with both the components i.e., Karanj cake and VAM together than the ones treated with either of the component alone. The effectiveness of both the pathogens was found to be enhanced in respect to increase in plant growth, mycorrhizal colonization, VAM chlamydospoers count in soil and decrease in population of nematode and fungal colonies. When both the management components were applied together to the plants, it was due to the combined effect of both the components. The outstanding performance of both the components is attributed to the strong nematicidal value of Karanj cake and VAM supplementing to the fungicidal property of the cake in addition to its nutritional value, which improved the general plant vigour as well.

Biochemical Markers for Predicting Resistance in Wheat against the Cereal Cyst Nematode, *Heterodera avenae*

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Wheat (*Triticum aestivum*) is one of the most important cereal crop of the country. A preliminary investigation was conducted to identify some enzymes [Peroxidase (PO), Polyphenol oxidase (PPO) and Phenylalanine ammonia lyase (PAL)] as biochemical indicators of resistance in wheat against the cereal cyst nematode, *Heterodera avenae*. Biochemical characterization of roots and shoots of eight wheat varieties/ accessions (Raj 1482; CCNRV-4; Raj 3077, CCNRV-1; AUS 15854; BK3105; CCNRV-2 and BK 3102) grown under similar agro-ecosystems was done and correlated with their resistance levels to cereal cyst nematode. The percentage difference in enzyme activity of PO, PPO and PAL in roots was recorded in the range of 285.7, 225 and 467.8 per cent respectively whereas the same in shoot was 88.4, 303.57 and 188.9 per cent respectively in the resistant cultivars CCNRV-4, CCNRV-1, AUS 15854, CCNRV-2 and BK 3102 as compared to susceptible cultivars Raj 1482 and Raj 3077. PPO and PAL showed higher percentage difference in enzyme activity as compared to PO. The wheat varieties were evaluated for cyst nematode resistance by inoculating 5 J2/g soil of *H. avenae* and studying their multiplication at the completion of the life cycle. Elevated levels of the enzyme activity in all the resistant cultivars could be attributed to the formation of lignins and accumulation of phenols at intra-cellular levels as products of phenylpropanoid pathway.

Developmental Biology of Potato Cyst Nematodes in Selected Potato Lines/Varieties

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The Potato Cyst Nematodes (PCN) are the major plant protection problem of Nilgiris that are managed by integrating several nematode management practices. The existence of three pathotypes in each of the two species and variations in the developmental biology of these species necessitated detailed studies on the larval hatch and cyst development in different potato lines having varied degrees of resistance to these nematodes. The larval hatch from the cysts was estimated by using the nematode cysts from the stock cultures separately maintained for *Globodera pallida* and *G.rostochiensis* at Central Potato Research Station, Ooty. These were separately mixed with sterile potting soil, so that each ml soil contained about 10 eggs and larvae. The soils were filled in 5 cm diameter earthen pots and were singly planted in five replicates with well chitted tubers of D/79-56, E/79-42 and CP1974 in comparison to standard potato cultivars Kufri Jyoti, Kufri Swarna and Kufri Giriraj. These pots were maintained at 18-20^{o} C under glass house conditions and each pot was provided with a petri dish to collect the root exudates. At periodical intervals of five days the larval count was made species wise. As there was absolutely no difference between species for larval hatch, the mean percent larval hatch to the total were made. The larval hatch started at 5 days of planting and up to 15 days there was no difference between susceptible and resistant potatoes. The maximum cyst hatch got completed in Kufri Swarna, a cyst nematode resistant potato by about 35 days after planting followed by E/79-42 and CP1974 while it continued up to 60 days in test lines/ varieties that were susceptible.

The development of cysts in another set of experiment indicated that, though the larval hatch had been almost uniform in the initial stages in all the varieties, the root system of Kufri Jyoti and D/79-56 (Kufri Thenmalai) showed very good development of PCN from 30 days onwards and touched to about 100 females per root ball just in 45 days. At the same time Kufri Giriraj showed less than 5 females per root system while in Kufri Swarna and CP1974 the nematodes could be categorized to species by the colour differentiation only at 60 days indicating delayed development of the nematode. About 2-3 females of *G. pallida* occurred on the roots of E/79-42 while it did not allow any development of *G. rostochiensis* indicating very high resistance to their development. The total number of PCN was just about 10 per root ball in Kufri Swarna as against more than 250 nematodes in Kufri Jyoti. Though Kufri Giriraj was susceptible to both species of PCN, which numbered to about 50 per root ball, their development was delayed till 60 days similar to that of resistant potatoes. Hence the relative effect of PCN was less pronounced in Kufri Giriraj under field conditions and thus was found suitable for integrated nematode management as it provided good resistance to late blight disease which is another major problem of potato in Nilgiris.

Bio-control of cereal cyst nematode, *Heterodera Avenae* in Barley using Bioagents

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Barley is an important rabi crop of rainfed as well as to less irrigation, low fertilization management even salinity / alkalinity. This crop is vulnerable to a number of pests and diseases which cause considerable reduction in yield. Amongst various disease causing agents nematodes, play an important role. The cereal cyst nematode *Heterodera avenae* is responsible for the serious 'Molya' disease of barley, yield reduction to CCN is about 50 percent in barley, which sometimes increased upto 60-65% at disease severity. An experiment using four bioagents *viz Trichoderma viride*, *Trichoderma harzianum* ,*Beuvaria* spp.and *Metarhizium* spp. used alongwith seed (seed coating(@ 6 g/kg seed) in barley against cereal cyst nematode was conducted at A.R.S. Durgapura, Jaipur infested field condition.(8.5 larvae/g soil). The carbofuran 3G@ 1.0 kg ai/ha was used as treated check along with untreated control. The observation *viz* grain yield & number of cysts per plant were recorded in each treatment separately. Present investigation revealed that highest grain yield were recorded in *Beuvaria* (grain yield-39.67q/ha) followed by *Metarhizium* (grain yield- 35.33 q/ha) as compared to untreated check (grain yield -20.67).The no. of cysts/plant have also been recorded. Of which *T. viride* (13.5), (*Beuvaria* (9.5), *Metarhizium* (11.5) over untreated control (21.0). However, *T. harzianum* did not show any marked reduction in CCN counts.

Management of root-knot nematode, *Meloidogyne incognita* in Round Melon

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Round melon (*Citrullus vulgaris*) is one of the important cucurbit crop cultivated all over the Rajasthan state in both summer and rainy seasons. Being susceptible to *Meloidogyne incognita*, it causes crop losses of about 25-30%. The present crop attempt is to manage the root-knot nematode in round melon, by using varied chemical applications (seed soaking and foliar spray). An experiment consisted of carbosulfan 25EC (as a seed soaker and foliar spray @ 1000ppm) and carbofuran 3G as alone and in combinations alongwith an untreated control was conducted (2.5larvae/g soil) at A.R.S., Durgapura, Jaipur in round melon to manage the root-knot nematode (*M.incognita*). The crop was allowed to run, fruit yield of crop and RKI of each treatment was recorded simultaneously. All the treatments were found to be effective in enhancing plant growth and yield alongwith reducing galls per plant. However, the treatment of Carbosulfan 25 EC (seed soaking) + Carbosulfan spray + reduced dose of Carbofuran 3G @ 1.0 kg ai/ha was found to gave the highest (yield – 71.67 q/ha and reducing number of galls per plant – 12.67) followed with carbosulfan 25 EC (seed soaking) + ½ dose of carbofuran 3G @ 1.0 kg ai/ha (yield - 59.59 q/ha and galls per plant - 16.00) as compared to untreated check (yield – 30.22 q/ha and galls per plant 41.00). As per above results the interaction of seed soaking, spray and reduced dose of Carbofuran 3G were able to minimize the development of nematode and also gave better yield as compared to untreated check.

Occurrence of Longidorid Nematode Species from the High Altitude Zone of Himachal Pradesh with Description of *Paralongidorus neoformis* sp. n.

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Longidorid nematode species viz. *Xiphinema, Longidorus* and *Paralongidorus* have attained a great importance by damaging a wide range of crops directly and also because of their ability to transmit different plat viruses in different fruit and vegetable crops. Keeping in view the importance of these longidorid species in nematode interaction with plat viruses, a comprehensive survey was carried out for assessing the incidence and distribution of these nematode species in temperate region, specially the high altitude zone of the state. It was revealed from the survey results that *X. solanensis, X. inaequale, X. insigne, X. basiri, L. citri, L. brevicaudatus, L. attenuatus, P. microlaimus* and *P. neoformis* sp.n were found in low to high population of occurrence from around the roots of fruit plants as pome, stone and strawberry crops. Out of these populations of Longidorid nematode species, *Paralongidorus. neoformis* sp.n., is described new in association with Ficus carica L. from Kullu, H.P. which comes close to *P. capensis* Heyns, 1966 but it differs in having relatively short body, more anteriorly located guiding ring, larger value of 'c' and differently shaped tail.

Nematode on Sugarcane Crop

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Amongst non-insect pest plant parasitic nematode are among the most important in exercising their influence in limiting crop production. In India loss of 7 to 52% due to nematode had been earlier reported by several workers. Keeping in view the experiment was laid in nematode infested sick microplot at SRI Pusa during 2003-04. Main treatments are solarised and unsolarised each with 5 sub-treatments viz. Baggasse (2 kg/m/2), Poultry manure (2 kg/m2), FYM, carbofuran (0.3 g a.i./m2), untreated control respectively. All the organics were amended in soil 4 weeks prior in plots except carbofuran which was applied at the time of planting. Observaitons on plant growth characters including yield as well as juice quality were recorded. Initial and at the time of harvest nematode populations were estimated from each plots. Initial average total populations of plant parasitic nematodes were 142 to 174 individual of different species per 100g soil consisting of *Helicotylenchus, Tylenchorlynchus* spp*, Meloidogyne incognita* and *Tylenchus* spp. Along with non-parasitic forms. Results indicated that total population of plant parasitic nematode enhanced by 133% in untreated control plots. If compared within the solarized and treated plots the most effective treatments were carbofuran and FYM followed by baggasse and oultry manure in decreasing the nematode population and increasing the cane yield significantly. It also reflects on the growth characters though juice quality showed non-significant.

Occurrence & Distribution of Reniform Plant Parasitic in Nematode, *Rotylenchulus renformis* Linford & Around Crops of Udaipur (Rajasthan) India.

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A field survey conducted during l987-1988 by collecting 674 soil and root samples from 37 localities to study the association of reniform nematode *(Rotylenculus reniformis*) with the available crops in and around Udaipur district of Rajasthan revealed that out of 676, 496 samples showed presence of *Rotylenculus reniformis* which constitutes 73.59% of occurrence in and around Udaipur. 100% occfurrence was found in six localities: 90% in three localities while as most of the remaining localities showed 51-90% of occurrence. Two localities showed below 50% of occurrence. The highest population density was found in Sundervas (68.60) while as low to moderate population density was found in all the localities on the crops viz.: Mustard,Barley, Onion and Wsheat. Study further ravealed that a few important crops viz: Castor, Brinjal, Tomato, Chilies and Okra were highly attacked by Rotyleuchus reniformis. The highest % population density of R. reniformis was found on castor (67.10%) with 100% occfurrence. 100% of occurrence was found on brinjal, Tomato, Chillies, Cauliflower and gram and less average % of population density was found on Mustard, Barley, Onion and Wheat. Similarly the prominence value was found on Berseem (lowest) and 671.07 on Caster (highest). Crops viz. Cucumber, Bitter gourd and water melon showed complete absence of Reniform nematodes in few localities.

Effect of Urdbean based Cropping Sequences on the Population of Root Knot Nematode, *Meloidogyne javanica*

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Introduction of non-host crops in the urdbean based cropping sequences may play important role in regulating the nematode populations. Therefore, the effect of four urdbean based cropping sequences on root knot nematode population was studied under micro plots of size 2X2.5m. Cropping sequences taken were, urdbean – wheat, Sorghum + urdbean – wheat, Urdbean – mustard – wheat and Maize – Potato – urdbean. Each sequence was replicated five times. The initial nematode population in microplots was 50 juveniles per 100 cc soil. With growing of urdbean during kharif, the nematode population increased to 100 juveniles per 100 cc soil and then reduced to 44 juveniles by growing of non-host crop wheat after urdbean. Urdbean followed by two non-host crops mustard and then wheat reduced the population more. When urdbean was grown as intercrop with sorghum nematode population did not build up and this followed by wheat further reduced the nematode population to 10 juveniles/100 cc soil. In the cropping sequence of Maize followed by potato and urdbean, although the nematode population reduced with growing of maize but increased in potato and further increased to 125 juveniles/100 cc soil at the end of urdbean crop during spring. This shows that after susceptible urdbean crop, one or two non-host crops may help in keeping the root knot nematode, *Meloidogyne javanica* population at lower levels reducing the damage in the susceptible crops.

Nematode Fauna Associated with Cultivated Crops in Saharanpur District, Uttar Pradesh.

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A survey was conducted for nematode fauna associated with horticultural and other crops standing in the orchards in Saharanpur. Localities were Fundpuri, and Nakur 14 and 25 K. M. from Saharanpur respectively on Saharanpur – Gangoh Road and Sarswan 14 K.M. from Saharanpur on Saharanpur – Ambala road.
Localities, Crops and associated nematodes are shown below

Occurrence of nematode in different areas associated with crops in Saharanpur.

Locality	Crop	Nematodes identified
Fandpuri	Mango	*Diphtherophora citri, Discolimus sp. Hemicriconemoides cocophilus, Tylenchorhynchus nudus, Helicotylenchus dihystera, Psilenchus hilarus,*
Fandpuri	Wheat	*Discolaimus sp., Hoplolaimus indicus, Tylenchorhynchus mashhoodi, Xiphinema insignis, Leptonchus sp. Psilenchus hilarus,*
Fandpuri	Sugarcane	*Aphelenchoides asterocaudatus, Acrobeloides sp. Amphidelus sp. Diphtherophora citri, Ironus iarius, Xiphinema insignis, Monohystera sp. Mylonchulus lacumurus, Hemicriconemoides cocophilus, Hoplolaimus indicus, Helicotylenchus indicus, H. astriatus, Trichodorus mirzai,.*
Nakur	Mango	*Aphelenchus avenae, Acrobeles sp. Diphtherophora delhiensis, Dorylaimoides sp. Helicotylenchus astriatus, Hemicriconemoides cocophilus, Hoplolaimus indiicus, Paratylenchus neonanus, Plectus sp. Trichodorus mirzai, Tylenchorhynchus brevilineatus, Rhabditid sp.*
Nakur	Jamun	*Aglenchus costatus, Acrobeloides sp., Dorylaimus sp. Hemicriconemoides cococphilus*
Nakur	Guava	*Dorylaimus sp.Partylenchus nainius, Hemicriconemoides mangiferae, Helicotylenchus indicus, Tylenchorhynchus mashhoodi,*
Nakur	Weed in mango	*Acrobeloides sp.,Diphtherophora citri, Helicotylenchus astratus, H. delhiensis, Hemicriconemoides mangiferae, Plectus sp. Tyleptus sp. Hoplolaimus indicus, Tylenchorhynchus mashhoodi,*
Nakur	Wheat	*Aphelenchoides asterocaudatus, Dorylaimus, Hoplolaimus indicus, Tylenchorhynchus mashoodi, Xiphinema basiri*
Nakur	Carrot	*Acrobeloides sp., Amphidelus, Aphelenchus avenae, Dorylaimus sp.*
Sarswan	Mango	*Aglenchus costatus, Acrobeloides sp., Discolaimus sp.Diphtherphora citri, Chromodora sp., Chronogaster n. sp., Hemicriconemoides mangiferae, Helicotylenchus indicus, Hoplolaimus indicus, Iotunchus sp., Ironus iarius, Rhabditis sp. Tylenchorhynchus nudus Mylenchulus lacumurus*
Sarswan	Turmeric	*Aphelenchoides asterocaudatus, Acrobeloides sp.,Boleodorus similis, Meloidogyne incognita, Micoconchus sp., Ironus iarius,*
Sarswan	Radish	*Cehalobus sp., Diphtherophora delhiensis, Dorylaimus sp., Leptonchus sp. Helicotylenchus cuspicaudatus,Psilenchus hilarulus, Tylenchorhynchus karnalensis, Tyleptus sp.*

The Nematode population indicates that *Hemicriconemoides cocophilus, H. mangiferae* were present in all fruit trees viz. Mango, Jamun, Guava, Sugarcane and weed in Mango orchard in all localities. *Paratylenchus neonanus* and *P. nainiauns* were found associated with Mango and Jamun in Nakur only. *Trichodorus mirzai* was found in associated with mango and Sugarcne in Fundpuri and Nakur only. *Meloidogyne incognia was found* parasitising turmeric in Sarswan..

Salvaging Seeds infested with 'White Tip Nematode of Rice' through Microwave Treatment

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Hot water treatment for salvaging paddy germplasm under exchange, from seed borne white tip nematode (*Aphelenchoides besseyi*) is tedious and time consuming as it involves - transferring seeds into cloth bags, labeling, carrying out hot water treatment, drying of seeds in cloth bags and repacking in new paper bags, after labeling. To simplify the procedure an easy salvaging technique was tried which could save time and labor, especially while dealing with a large number of international trials and nursery trials which are exchanged in standard size and coloured paper packets, from International Rice Research Institute, Philippines. Paddy seeds with or without soaking, outside (in plastic petridish) or in the paper bags were exposed to microwave oven for different time intervals. A lot of 10 packets, in 'yellow colored paper bag' (of size 2" by 3") having 25 gm of seeds each required as exposure of at least 50 seconds to kill all (100%) nematodes. Lower exposures to the oven reduced nematode inoculum but could not control/ salvage (100% kill of nematodes) seeds in the packets. The germination and vigor (root length and shoot length after 8 days in germination towel) of the seeds was not affected at 50 or 60 seconds period of exposure to microwaves of 2450 MHZ. Relationship among time of exposure, quantity of seeds in the packet, number of packets in the oven for each exposure, moisture content of the seeds, germination and vigor after each exposure are being worked out to make the technique useful for processing paddy germplasm samples under international exchange.

Effect of *Rhizobium* on *Pisum sativum* infected with *Meloidogyne incognita* Grown in Fly Ash Amended Soil

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Fly ash amended soil was prepared by mixing clayey loam soil with fly ash in the proportions of 9:1, 8:2, 7:3, 6:4 and 5:5, respectively. The roots of two- leaf stage seedlings of *Pisum sativum* were treated with *Rhizobium*. The treated seedlings were transferred to 15cm diameter clay pots. After three days of transplantation, the plants were inoculated with second-stage juveniles of *Meloidogyne incognita* at the rate of 2000 J_2 per pot. One set of plant neither treated with *Rhizobium* nor inoculated with *M. incognita* and grown in unammended soil served as control. The plants were watered regularly and were harvested 45 days after inoculation. The data revealed that the growth, in terms of length, fresh weight and dry weight, of plants inoculated with nematode only decreased significantly (P=0.01) when compared with control. The growth of *Rhizobium* treated plants increased when compared with nematode inoculated plants. A significant (P=0.01) reduction in yield in terms of number of flowers and fruits was found in nematode inoculated plants in comparison to control plants. It was further noticed that plant growth and yield decreased at higher concentrations of fly ash then at lower concentrations. The nodulation was found to be maximum on the roots of plants that were grown in normal soil and were nor inculcated with the nematode. The number of nodules decreased in all fly ash amended treatments.

Monitoring for Invasive Alien "Pine Wilt Nematode" in Himalayas

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The Himalayas have extensive conifer forests of blue pine (*Pinus wallichiana*), chilgoza pine (*Pinus gerardiana*), fir (*Abies spectabilis*), silver fir (*A. pindrow*) and spruce (*Picea smithiana*) all susceptible to pine wilt disease. Surveillance for the occurrence or introduction of harmful organisms which may become invasive alien species is an important component of plant protection and quarantine. Knowledge on the global occurrence/ distribution of pine wilt nematode (PWN), *Bursaphelenchus xylophilus* and on possible pathways of introduction to clean areas is essential for early warning and for taking precautionary measures against the introduction and spread of the nematode. Surveillance strategies need to planned and initiated in the Himalayas by quarantine scientists under four different approaches (a) general monitoring (b) import monitoring (c) export monitoring and (d) area-wide monitoring.
The general monitoring contributes to the overall surveillance of invasive species. The PWN has already got introduced and causing economic losses in China, our neighboring country which shares Himalayan Mountains and international borders with India, Nepal, Bhutan, Myanmar and Pakistan. The information needs to be gathered in the framework of the general monitoring for coping with the requirements set out under the International Plant Protection Convention (IPPC) under the related International Standards for Phytosanitary Measures (ISPM) in respect of pest reporting (ISPM 17) and determination of the status of serious pests in an area (ISPM 8). The data is essentially required to be generated for pest risk analysis (PRA), to restrict imports from the countries where PWN has been reported, for assurance to the importing countries/ issuance of phytosanitary certificate – to our export commodities or packing material originating from the area and treating/ declaring the nematode as a pest of high quarantine importance to the country.
For economical reasons low grade and untreated wood has been frequently used as packing material under exchange. A large number of pests and diseases of quarantine significance to forest trees have spread through timber. Until recently packing wood was not subjected to phytosanitary controls as there was neither an obligation of "Phytosanitary Certificate" nor for a declaration in the import documents. The IPPC enacted two "Emergency Decisions". According to latest regulations, the compliance decisions of the packing wood needs to be checked by the responsible bodies of the member countries and a report on the monitoring results has to be submitted to the IPPC. To meet the requirement Himalayan mountains, covered with pine forests need to be put under surveillance for PWN, movement of plants, planting material, imported packing material, logs, chips, timber and wooden furniture. All efforts need to be made to keep the areas diseasefree from getting inoculum (of PWN and insect vector) from infected countries by placing regulatory legislation and the implementation of quarantine strategies as a filter.

Biodiversity of Plant Parasitic Nematodes in H.P.

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Survey conducted in rice-wheat and maize-wheat cropping system in H.P. revealed the predominant presence of *Helicotylenchus dihystera* followed by *Tylenchorhynchus mashhoodi*, *Pratylenchus zeae, Hirschmanniella gracilis, H. oryzae, Tylenchorynchus nudus* and *Macroposthonia xenoplax*. In maize-wheat, *Hirschmanniella* spp. were not present but *Hoplolaimus indicus* was abundantly observed. Soil sampling done in the month of September showed usually high number of nematode populations in maize-wheat rotation whereas in rice-wheat system, higher density of nematodes was recorded in wheat season i.e. in the month of April. In higher places like Shimla, Solan and Kinnaur areas of H.P. where mostly maize-wheat cropping system was practiced, *Tylenchorhynchus* spp., *Helicotylenchus* spp. and *Pratylenchus* spp. were encountered in large numbers. Other nematodes recorded in these samples include *Hoplolaimus indicus*, *Meloidogyne* sp., *Hirschmanniella oryzae*, *Hemicriconemoides* sp. and *Longidorus* sp. Population of *Paratylenchus* sp. and *Aphelenchoides* sp. were also observed in good numbers in some of the samples especially in Manali area. New species of tylenchid nematodes, *Tylenchorhynchus karnalensis, Helichotylenchus cuspicaudatus, H. bajoriensis*, *Scutellonema himachalensis,* and a dorylaim nematode, *Xiphinema mali*, were reported. A new species of cyst nematode, *Heterodera skohensis* n.sp. infesting rice was also found. Other cyst nematode species encountered during survey in H.P. *were H. avenae, H.iri,* and *H.filipjevi* on wheat, *H. zeae.* and *H. sorghi* on maize *, H.cajani* on cowpea, *H. graminis* on grass*, H. mothi* on nut grass and *Cactodera johanseni* in maize fields*.*

Organic Management of *Meloidogyne incognita* infesting Okra

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Use of organic products against pest and disease (*Meloidogyne incognita*) on economically important crops is often emphasized in organic farming. Organic material such as neem oil smearing (1% w/w) of okra cv. Pusa kranti, and soil amendment with *Datura stramonium* and *Calotropis procera* leaves 5% (Contain alkaloids like Scopolamine/Hyocymin) alone and in combination with kalisena (a commercial formulation of *Aspergilus niger bioagent (*Aflatoxin producing fungi*) and biofertilise, AN 27 SD* egg parasitic and toxin producing facultative fungi*)* and *Trichroderma harzianum* as seed treatment (1% w/w) against *M incognita* showed that *Calotropis sp* and neem oil alone mitigated root knot galls by 62%. In combined application reduction in nematode multiplication was not enhanced than the alone treatments. Neem oil, *T hazianum* and and dhatura in combined application affected root knot galling maximum by over 70%. While kalisena in the same combination was not so effective in reducing the number of galls Plant growth such as shoot length, root and shoot weight was improved in organic amended soil.

Nemic bio-diversity in Seven Districts of Southern Gujarat, India

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Systematic survey of seven districts (Surat, Bharuch, Navsari, Vadodara, Narmada, Valsad and Ananad) of Gujarat, India was conducted to know the biodiversity of plant parasitic and beneficial nematodes. Altogether 48 soil samples were collected from the rhizosphere of different vegetable, cereal, oil-seed and fruit crops. Analysis of different crops revealed the occurrence of 18 genera of beneficial and 17 of plant parasitic nematodes. The mycetophagous nematode *Aphelenchus avenae* was the most frequently occurring with its relative frequency (30.5%) followed by *Cephalobus persegnis* (14.7%); *Leptonchus capitatus* (9.4); *Alaimus* sp.; *Ditylenchus triformis* and *D. myceliophagous* (5.2), and the minimum being for rhabditids and *Nygolaimus* sp. (1.05%). Among the plant parasitic nematodes *Helicotylenchus indicus* and *H. retusus* were the most frequently occurring with high relative frequency (29.74%), followed by *Pratylenchus zeae* and *P. brachyurus* (14.86%), *Tylenchorhynchus brevilineatus, T. nudus* and *T. mashhoodi* (9.46%), *Rotylenchulus reniformis* (8.11%); *Hoplolaimus indicus* and tylenchidae (6.75%), *Meloidogyne incognita, M. javanica* and *Scutellonema unum* (5.40%), and the least being for 10 other tylenchid species. Among the beneficial nematodes, *Ditylenchus* spp. was recorded to have maximum relative density, (38.1%); followed by *A. composticola* (7.0%); *C. persegnis* (4.2%), *Plectus* sp. (4.0%), *Alaimus* sp. (3.7%), free living dorylaims (3.7%), *A. avenae* (3.4%), araeolaimids (2.4%), enoplids (1.6%) and *Mylonchulus* sp. (1.2%). In case of plant parasitic nematodes, maximum relative density was recorded for *Tylenchus* and allied genera (6.2%),followed by *Meloidogyne* spp. (5.6%); *Tylenchorhynchus* spp. (5.0%); *Pratylenchus* spp. (4.22%); *Helicotylenchus* spp and *R. reniformis* (3.9%) and *Hoplolaimus indicus* (1.2 %). In Valsad, despite having very high nematode density, the proportion of beneficial nematodes was only 15% and the remaining 85% were plant parasites. In other 6 districts, the percentage of beneficial nematodes varied from 47 to 69%, minimum being in Narmada and the maximum in Vadodra.

Differentiation of Three Indigenous Strains of *Steinernema* spp. based on RFLPs of ITS Region of rDNA

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RFLP (restriction fragment length polymorphism) profiles of the amplified products of ITS (Inter-transcribed spacer) region of rDNA using four restriction enzymes (*Alu* I, *Rsa* I, *Hinf* I and *Hha* I), revealed polymorphism among the three indigenous strains of *Steinernema* (*S. thermophilum*, strains IARI-EPN-up2 and IARI-EPN-mg1 of un-described species). The restriction patterns obtained by using *Alu* I digest, could distinguish all the three strains from one another, and hence were found to be species specific. Other three restriction enzymes could differentiate *S. thermophilum* from the two strains of un-described *Steinernema* spp., but the restriction patterns of the latter two strains were found to be similar. The sequence variation in ITS region as evident from the differences in RFLPs, can be useful for the molecular taxonomy of *Steinernema* species.

Identification of Symbiotic Bacterium and other Bacteria associated with *Steinernema thermophilum* Ganguly & Singh

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The symbiotic bacterium associated with entomopathogenic nematode, *Steinernema thermophilum* Ganguly & Singh, 2000, was isolated from infective juveniles (IJs) and characterized. Based on the phenotypic, cultural, biochemical and molecular characteristics, it was proposed as a new species of *Xenorhabdus*. Phylogenetically, the new species was found to be most closely related to *X. poinarii*. During the course of isolation of the bacterial symbiont of *S. thermophilum*, some other species of bacteria were also encountered. In all the five isolations of the bacteria from nematode IJs reared on *Galleria mellonella,* another enterobacter, *Providencia* sp. was also recovered, which is also proposed as a new species. But, IJs reared on yellow meal worm, *Tenebrio molitor*, revealed the presence of another bacterium identified as *Morganella morganii* subsp. *morganii* (Winslow *et al*., 1919) Fulton 1943, and not *Providencia*. It indicated the presence of another enterobacter species varying with the host, along with the symbiotic bacteria, *Xenorhabdus*. Therefore, we hypothesise that some other enterobacter, probably of host's origin, may also be involved in the insect- *S. thermophilum* - *Xenorhabdus* complex.

The other bacteria observed growing on some of the plates, and suspected to be contaminants were: *Chryseobacterium meningosepticum* (*Elizabethkingia meningoseptica*) (King 1959) Kim *et al.* 2005, *Alcaligenes faecalis* Castellani and Chalmers 1919*, Leucobacter* sp.nov.

New Record of an Entomopathogenic Nematode, *Steinernema siamkayai* Stock, Somsook & Reid, 1998 from Champawat District of Uttaranchal, India

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A strain of *Steinernema* sp. was isolated from the soil samples collected from the rhizosphere of litchi (*Litchi chinensis*) in Champawat district, Uttaranchal State, by baiting the soil samples with 4th instar larva of *Galleria mellonella.* This strain was found to have very high insect biocontrol potential, since it could induce insect mortality with in 24 –48 hrs and its IJs emerged *en masse* from the cadaver with in 3 to 4 days after the inoculation, at 25-30°C. This strain was designated as IARI-EPN-ut1.

Detailed morphological and morphometrical studies of the strain IARI-EPN-ut1 was undertaken, which revealed it to be closely resembling *Steinernema siamkayai* Stock, Somsook & Reid, 1998 in most of the characters. The IJs of this strain exhibited some differences from the type measurements of *S. siamkayai,* by having posteriorly located excretory pore (37-40 μm vs. 29-28 μm) and longer Tail (43-46 μm vs 31-41 μm), which were considered as intraspecific variations of *S. siamkayai*. Biochemically, this strain was distinctive from other native species / strains of *Steinernema* spp. by having distinct isozymic profiles of b-esterase of its infective juveniles.

The males and females of two generations of this strain were also in confirmity with this species. The strain was thus identified as *S. siamkayai,* which is perhaps the first report of this species from Uttaranchal state in India.

Meloidogyne incognita a Problem on Tuberose in Khatoli (Muzaffarnagar, Uttar Pradesh) with Bulbs as a Source of Infection.

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The fields with tuberose cultivation in the Khatoli, Muzaffarnagar District, U P were surveyed for nematode problems in September 2004. Different fields in all the five villages surveyed showed patchy growth of tuberose with plants of different height and spreading in the patch. These plants were pale in color had none or short spikes with lesser number of flowers per spike. Roots of the plants, in all the villages showed heavy galling. Bulbs with roots were brought to the laboratory and the nematode was identified to be *Meloidogyne incognita*. Root knot population in the soil varied from 2.7 to 19.7 J2s /cc soil. Apparent damage to the tuberose was > 50% in many fields. Examination of the bulbs, that the farmers had harvested a few months ago and kept for seed purpose, showed root knot galls on the attached roots. These bulbs were collected and stored at room temperature for six months. The roots of a few bulbs were removed prior to storage. Bulbs with and without attached roots were sown in pots with sterilized soil. Observations on presence of galls were made 60 days after sowing. In each case 30 to 40 percent of the plants from these bulbs developed root knot infection. Removal of attached roots did not make a difference in development of infection. Fully developed egg masses (with eggs) were attached to the galls. Thus, it is inferred that the nematode survives in the bulbs for several months and that the bulbs are one of the source of infection. The management options, therefore, should focus on the treatment of the bulbs to prevent the spread of the problem from one area or season to another.

Survival of *Steinernema thermophilum* in an Alginate-based Formulation

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Formulations of infective juveniles (IJs) of *Steinernema thermophilum* were prepared in 0.5, 1.0, 1.5 and 2 % calcium alginate to standardize the appropriate concentration for storage. Percent IJs retained were maximum in 2% alginate (89.6%), followed by 1.5 (50.1%), 1.0 (46.4 %) and the least in 0.5% alginate (2.9%).Based on the number of IJs retained in the gel and their percent survival during storage, 2% alginate was found to be the most appropriate. Thereafter, shelf-life of 2% calcium alginate formulation in the form of beads of 5mm diam. containing 500 IJs/ bead, was studied. These were kept at two different temperature conditions, one in BOD incubator at 25^0C and another at room temperature varying from 19 to 37^0C during October, 2004 to May, 2005. Observations on survival of IJs/bead were recorded after every one month upto 7 months. At 25^0C, the survival of IJs was 100 % for the first two months, 94% after 5 months, 77.6 % after 6months and then declined to 54% after 7 months. At room temperature, the survival was upto 91.9% after 5 months storage (October to March, the average maximum room temperature was 19-32^0C) that was almost at par with that of 25^0C. After 6 months, ie by April, the survival of IJs declined to 21.8%, which further declined to 2.5% after 7 months in May. The sharp decline in survival after 6 and 7 months storage was attributed to the high temperature conditions (34-37^0C in April and May).It was thus indicated that high temperature (>32^0C) and prolonged storage (6-7 months) adversely affected the shelf-life of the IJs in alginate formulation.

Compatibility of Fungal Bioagents as Seed Dressers with Carbofuran in Okra against *Meloidogyne Incognita*

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Kalisena (a commercial formulation of *Aspergilus niger,* a boagent and biofertilizer, AN *27 SD an* egg parasitic and toxin producing facultative fungi) and *Trichoderma harzianum* as seed treatment (1% w/w) of okra cv. Pusa kranti against *Meloidogyne incognita* alone and in combination with carbofuran 0.5Kg ai./ha were evaluated in 6" earthen pots with three replication in completely randomized design. Inoculum load of *M incognita* was maintained as $2J_2$/cc soil and observation on nematode multiplication was recorded after 45 days of inoculation. Perusal of the results indicated that Kalisena and *T. harzianum* were more effective in combined application with carbofuran as it reduced root knot galling by 20-50% in comparison to alone application 10-20%. Comparatively *T harzianum* was better than the kalisena in reducing the root knot damage in combined application and vice versa was true in alone treatments. Increase in dose of bioagents apparently did not show better effect in reducing root knot damage. Plant growth such as root and shoot weight was better in alone treatments of bioagent than the combined application with carbofuran.

Optimum Storage Conditions for Prolonged Survival of *Steinernema thermophilum*

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Experiments were conducted during 1999-2004 to standardise the optimum conditions for prolonged survival of infective juveniles of *Steinernema thermophilum* Ganguly & Singh, 2000. The aqueous suspensions of infective juveniles in tissue culture flasks (growth area 75 square cm), in two different concentrations (1000 and 5000 IJs /ml) and volumes (25 and 50 ml), at five different temperature conditions (10, 15, 20, 25 and 30^0C), were placed horizontally. Observations on survival of IJs were recorded initially at weekly intervals up to 24 weeks and thereafter at a period of 3 months upto 36 months. The two concentrations did not show any adverse effect on the survival of IJs. The nematodes placed in 25 ml volume showed significantly higher survival (97.5%) than those in 50 ml suspensions (14 %), after 24 weeks storage period. Up to 16 weeks, the survival was maximum (97.5 -100 %) at 15, 20 and 25^0C. After 24 weeks, the best survival percentage was recorded at 15^0C, followed by 20, 25, 10 and 30^0C. Thereafter, the observations were recorded only at 15^0C up to 36 months. The survival recorded was 84.4, 72.9, 67.3, 37.5 and 13.9% after 9, 12, 18, 24 and 36 months storage period, respectively. Hence, it can be inferred that for prolonged survival of *S. thermophilum*, the IJs should be stored in 25 ml aqueous suspensions, at concentration (1000-5000 IJs/ml), in tissue culture flasks (growth area 75 square cm), placed horizontally, at 15^0C.

Use of Remote Sensing and Geographical Information System in Regulatory Nematology

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Remote sensing technology has received considerable interest in the field of plant protection sciences because it provides synoptic view, multispectral data, multitemporal coverage and cost effective survey and surveillance of crops. It provides a wide range of sensor systems including aerial photographs, satellite imagery and spectrometer measurements. The technologies have many attributes that allow their use in plant nematology where ever symptoms are produced on the foliage *viz*. data collection, analysis of invasive nematodes, their abundance, distribution, mapping, modeling and factors influencing their distribution. The techniques are useful to photograph vegetation, plant species attributes such as canopy architecture, vegetative density and yellowing of leaves.

Pine wilt disease is one such disease where survey work is essentially required to declare the country disease free to gain the advantage under Sanitary and Phytosanitary Agreement of WTO; of export of wood, timber, chips, furniture and packing material made of cheap coniferous wood. The disease symptoms produced are quite distinct to record the data; to do mapping and monitoring the invaders through these advanced techniques. The nematode once introduced in an area can kill pine trees in six months. The pine wilt nematode has established in many disease centers in our neighboring country China and an emerging problem in Europe. The modern techniques have advantage over routine sampling and extraction of nematodes where the areas to be covered are huge, having complex geographical terrain types and diverse inaccessible ecosystems, as is the case in Himalayan pine forests. The Convention on Biological Diversity (CBD) to which India and 177 other countries are party, calls on member countries to “prevent the introduction, control or eradicate those alien species which threaten ecosystems, habitats or species” (Article 8h). There are no statistics on status of alien nematode species, theirs potential to enter, establish and spread where we nematologist should contribute.

Arabidopsis thaliana*, a Non-host for Pigeon Pea Cyst Nematode, *Heterodera cajani

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Arabidopsis thaliana is a small flowering plant that is widely used as a model organism for basic research in genetics and molecular biology. In nematology it has been used to study nematode feeding interactions at histochemical, cellular and molecular levels for both cyst and root-knot nematodes. Research reports with respect to cyst nematode usually confine to *Heterodera schachtii* and *H. glycines*, both of which do not occur in India and as a result no reports of work with *Arabidopsis* and cyst nematodes have origin in India. Considering the short life span of *Arabidopsis* (6 weeks), the plants were inoculated with pigeon pea cyst nematode, *Heterodera cajani*, a native cyst nematode species, which completes its life cycle in about 4 or less weeks of time. Observations at weekly intervals from the inoculation date till crop harvest did not show any sign of nematode infection. No surviving *H. cajani*, larvae were obtained on soil washing at crop maturity, thus indicating it to be a non-host plant for the pigeon pea cyst nematode, *H. cajani*.

Development of an *in-vitro* System for Testing Toxicity of Annexin cDNA Protein against *Meloidogyne incognita*

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A popular tomato cultivar, Pusa Ruby was transformed with annexin like protein coding cDNA (sequence No.U28415) using *Agrobacterium tumefaciens* based system to enhance its inherent resistance against the root-knot nematode, *Meloidogyne incognita*. This cDNA was subcloned and overexpressed in the pET21d expression vector and gel purified. The effect of this annexin cDNA encoded protein on *M. incognita* J2s was investigated *in vitro* at protein concentrations; 33µg/µl; 16.5µg/µl ; 8.25µg/µl; 4.12µg/µl and 2.06µg/µl for 24, 48 and 72 hrs. Sterile de-ionized water served as the control. The experiment was conducted with three replications each. No casualty of M. incognita juveniles was observed in any of the treatments however the larval movement was relatively slow at the highest concentration when exposed for 72 hrs. This indicated that the gene product was not toxic and the enhanced resistance in transformed tomato plants was because of the role of this protein in managing the biotic stress levels in the plants. The cDNA product has been reported to mimic the activity of peroxidase, a known stress buster enzyme in plants, and positively related to root-knot nematode resistance in tomato.

Plant Parasitic Nematodes Piversity under Different Cropping Systems

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The plant parasitic nematodes diversity observed under different cropping systems at Modipuram (U.P.) revealed the presence of five genera of *Tylenchorhynchus, Hoplolaimus, Helicotylenchus, Pratylenchus* and *Rotylenchulus.* Out of these four species viz *T.mashhoodi*, *Hoplolaimus indicus*, *Helicotylenchus dihystera* and *Pratylenchus zeae* were predominantly present with 100 per cent frequency distribution in all the treatments whereas *Rotylenchulus reniformis* was observed with 70 per cent frequency. It was also discernible from the data that there was a clear preference of a particular crop rotation for a particular nematode. *T.mashhoodi* was maximum in Sorghum (F)-wheat rotation, *H. indicus* was more in maize-wheat, *P. thornei* was more in Sugarcane-Ratoon-Wheat and *R. renformis* liked pigeonpea-wheat cropping system. But *H. dihystera* was favoured by Rice-wheat and Sugarcane-Rice-Wheat cropping system. Although, Sugarcane-Ratoon-Wheat rotation had maximum numbers of *T. mashhoodi* but less than that obtained in Sorghum (F)-Wheat rotation. So, a particular cropping pattern was responsible for increase in numbers of a particular species of nematodes.

Influence of Pigeonpea Based Cropping Systems on Population of Key Nematodes

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An intensive survey was initiated in the Kazipura and Dasna villages of Ghaziabad district in pigeonpea. The pigeonpea growing fields were initially surveyed for locating the infestation of pigeonpea cyst nematode, *Heterodera cajani*. Majority of the fields showed the presence of this nematode, but only ten fields were selected having high population of *H. cajani*. Monthly observations were recorded from these selected sites. The population of key nematode pest i.e. pigeonpea cyst nematode, *H.cajani* and the population level of root-knot(*Meloidogyne incognita)* and reniform (*Rotylenchulus reniformis)* nematodes were recorded. Monthly observations revealed the continuation of the nematode problem of pigeonpea cyst nematode, which was also associated with wilting at many places. The presence of brown cysts was recorded from many sites at varying numbers.The juvenile population was found at reducing stage in the absence of main host. The inter-cropping with Bajra did not support nematode population at the similar rate. There was constant increase in juvenile population from the pod formation to ripening phase of pigeonpea. The other plant parasitic nematodes did not show much damage.

Occurrence of the spiral nematode, *Helicotylenchus multicinctus* in Goa

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Soil samples collected from the rhizosphere of banana in Goa revealed the presence of a bisexual species of *Helicotylenchus* having about 50% males in the soil population. The female had hemispherical tail. The didelphic, amphidelphic females had prominent spermathicae. On comparison of the morphological characters with the original description of type specimens and key to the species of the genus it was identified as *Helicotylenchus multicinctus*, which is a well known parasite of banana roots and rhizomes. This appears to be the first report of the occurrence of this economically important nematode in the state of Goa. This species is already known to occur in some states of Indian mainland and in the Andamans.

A community analysis of the soil nematode fauna of Goa

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A random survey of soil inhabiting nematodes of Goa revealed that the spiral nematodes (*Helicotylenchus dihystera* and *H. multicinctus*) were the most predominant plant parasitic nematodes followed by the reniform nematode, *Rotylenchulus reniformis* and root knot nematode, *Meloidogyne incognita* in decreasing order of their prominence values. Occurrence of the burrowing nematodes, *Radopholus similis* and *H. multicinctus* at high population densities was recorded in coconut and banana, plantations, respectively.The other plant parasitic nematodes encountered were species of *Tylenchorhynchus, Hoplolaimus*, *Pratylenchus*, *Heterodera* and *Longodrus* with low frequencies and densities. The nematode community had about 66% free living rhabditids, dorylaims and other nematodes. Predatory mononchids were also found in 56.5% of the samples.

Cordyline terminalis – a monocot plant-host of *Meloidogyne incognita*.

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Commonly called as 'ti' plant, *Cordyline termimalis* is a monocotyledon belonging to family agavaceae. This ornamental plant is attractive and durable both as foliage and as landscape. A few plants of same age when planted to 30 cm wide cement pots at IARI, New Delhi showed poor growth. After six years, a poorly growing plant was found to be 45cm in height with an average leaf length of 15cm as compared 100cm height and 50 cm leaf length in a healthy plant of same age. Unlike healthy plant, examination of the poorly growing plant revealed the presence of galls on the roots. Further examination in the laboratory confirmed the presence of root-knot nematode. The nematode was identified as *Meloidogyne incognita*. These plants are reported to be infected by *Aphelenchoides olesistus, Rotylenchulus reniformis* and *Pratylenchus* spp. This apparently is the first report of this plant being infected with *M. incognita*.

Nematode Biodiversity and Systematics

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Biodiversity or biological diversity refers to the range of organic forms, their species and the genetic diversity within the species. So far, approximately 1.7 million species have been identified and named, which is less than 5 % of the estimated 30 million species present on the earth. Nematodes are amongst the most diverse taxa on earth, with an estimated 500, 000 to 1,000,000 species, of which only 30,000 species have been described so far. It has been estimated that India accounts for about 2 % of Earth's landmass, and it sustains atleast 6% of its biodiversity. It follows that at least 30,000 to 60,000 species of nematodes are expected from this country alone, while the described species are still less than 4%. Unfortunately, because of our ignorance, the world's biodiversity resources are depleting at faster rate than the discovery of new ones, and it is likely that one half of the existing forms may become extinct within our life time. Biodiversity is essential as it contributes to a wide variety of environmental services like regulation of the gaseous composition of the atmosphere, protection of the coastal zones, regulation of hydrological cycle of climate generation and conservation of fertile soils, disposal and breakdown of wastes and human health through medicines and drugs. Nematode biodiversity can be of immense value in biomonitoring, as indicators of soil health, disturbance in the ecosystem, pollution level, deep-sea mining etc. During the last decade, there has been tremendous awareness and debates on the issues of biological resources, their protection and conservation, and Intellectual Property Rights (IPR), revolving around the two international treatise: Convention on Biological Diversity (CBD) and the Trade-Related Intellectual Property Rights (TRIPS). In India, the National Biodiversity Authority (NBA) has taken the initiative to implement the Biodiversity Act 2002 by forming State Biodiversity Boards (SBB) in 9 states, and also Biodiversity Councils (BCs) to monitor and implement the Biodiversity Management Committees (BMCs) in Union territories.

Strengthening biosystematics research is extremely essential for the accurate identification of the species and knowing their genetic diversity, which forms the basis for exploiting the use of vast biodiversity resources, as well as their management. The identification of not only plant parasitic nematodes, but also free-living bacteriophagous, mycetophagous, saprophagous, omnivorous and predacious nematodes, and their precise role in the soil ecosystem, also needs to be addressed. The increasing emphasis on organic farming is also a step towards conservation of biodiversity. Adopting non-chemical methods for managing pests and diseases, have become mandatory. It is well known that non-chemical methods of nematode management (like crop rotation, resistant varieties, biological control, quarantine and regulatory measures) are highly specific in nature and hence rely on not only accurate species identification, but also precise information on host range, race status, biological and ecological characters of the target nematode species. The situation now demands to develop a sound information base on the important plant parasitic nematodes (Heteroderidae, Meloidogynidae, Pratylenchidae, Hoplolaimidae, Tylenchorhynchidae, Longidoridae), about their species, races, identification / pictorial keys, compendia, geographical distribution, etc. Intraspecific categories (races / biotypes) of agriculturally important species, need to be adequately addressed on the basis of host range, molecular data and information available from ethological, biological and ecological sources so as to have highly predictive value. Taxonomists are no longer confined to conventional approach

employing morphological details revealed through Light microscopy (LM), but also Scanning electron microscopy (SEM). Besides, several other approaches viz. numerical, cytogenetical, biochemical and molecular, are also being applied in nematode biosystematics for solving certain subtle problems in identifying the species, host races and sibling species. Numerical approach has also been applied for developing the computer-based species identification programmes especially for genera having large number of species. Cytogenetical approach in nematode biosystematics has been applied, but it has limited applicability. Biochemical approach based on isozymic profiles of b-esterase and some dehydrogenases has been used to differentiate some of the species of *Meloidogyne* and some other genera. But, it could not differentiate all the known species, therefore, it has now been replaced by molecular approach using DNA based technologies. Sequencing and alignment of the highly conserved 16SrDNA or entire ITS region, have been of immense value for differentiating the species and the higher categories, and deducing their phylogenetic relationships. Currently, DNA-DNA hybridization is being used for differentiating the bacterial species, which can also be applied in nematode systematics. In the recent past, remarkable progress has been made in the area of entomopathogenic nematology, wherein more than 40 species of *Steinernema* and 10 species of *Heterorhabditis* have already been described from various parts of the world, including 5 from India, while a very large number of isolates are still in the queue for identification. In this group, it is now mandatory to supplement the morphological and morphometrical details of five life stages, with SEM details of spicules, genital papillae and lip region; molecular data; interbreeding test; temperature requirement, life cycle and pathological information. The biosystematics' resources in terms of collections, taxonomic literature, taxonomic expertise, technical support, good microscopes, live cultures of different isolates of important nematode species, and the facilities for molecular analysis, needs to be strengthened, for which continuous institutional support is required. It can thus be concluded that biosystematics forms an integral part of the nematode biodiversity, and therefore strengthening of the biosystematics research is urgently needed for assessing the current state of nematode biodiversity, its management, conservation and sustainability, and subsequently its usage for the mankind.

Molecular Basis of Plant Nematode Interaction and Genetic Engineering for their Management

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Worldwide crop losses to plant parasitic nematodes have been estimated to about $78 billion annually. Root knot and cyst nematodes of the genera *Meloidogyne*, *Globodera*, and *Heterodera* are regarded as the most wide spread and important limiting factors in all type of agricultural systems. They have a very complex interaction with their host plant and have the capability to interfere with host plant gene expression. The symptoms produced, selection of the feeding cell/site, its formation and maintenance as a food source throughout indicate a set of compatible interactions. Evidences for some of these interactions at molecular level have already been documented. Nematode esophageal secretions carry signals for up/down - regulation of specific genes ultimately leading to compatible or incompatible interactions with the host plants. Several gene products have been identified that are secreted by the plant parasitic nematodes during parasitism. Genes likely involved in parasitism of plants as well as host resistance genes have been isolated and cloned. Characterization of genome of *Caenorhabditis elegans* and related functional genomics has opened entirely new fields of research which will expedite the isolation and cloning of genes from plant parasites and lead to better understanding of life processes of nematodes as well as the parasitic interactions with plants.

Genetic engineering offers new avenues of nematode management, based on the identity of crucial elements required for the both favourable or unfavourable interaction between plant parasitic nematodes and host crop plants. Developing transgenic plants with cloned resistance genes against specific nematodes, can be one successful strategy to fight nematodes. Strategies can be developed to disorient nematode in selecting the feeding site and manage gene expression so as to prevent development of feeding cell/site apart from using resistance genes or other strategies which aim at destroying nematode using toxins. Genes which have the ability to affect the digestive and reproductive system of nematodes have a great potential to be engineered in the crop plants for managing a wide spectrum of nematode pests as compared to specific resistance genes. Proper targeting of these gene products can be assured by using nematode responsive elements from available promoters or sets of promoters with common activity at the site of interest. Knowledge emanating from the genome sequencing projects in progress for root knot and other plant parasitic nematodes by various research groups in US and Europe should be able to generate additional information for developing alternative methods in the near future. New defence mechanisms may be bioengineered into plants to encounter nematodes in the rhizosphere or as they parasitize the prospective host.

Research efforts are being made to identify target specific chemicals which may interfere in the adaptive processes like nematode egg hatch and chemotaxis and or the gene products that control them. Comprehension of the immense knowledge at molecular level holds a great potential in managing nematode problems in future but safety concerns of genetically modified food as well as the environment need to be evaluated thoroughly before any of these strategies is launched in public.

Phytosanitary Issues in Plant Nematology

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Plant parasitic nematodes generally spread through the movement of infested planting material, soil clods mixed with true seeds and in few cases through true seeds. The Sanitary and Phytosanitary (SPS) Agreement of WTO relates to the risks associated with plants/ animals or humen diseases/ pests through international exchange or movement. The Agreement directly deals with the phytosanitary and quarantine aspects where as the one on Technical Barriers to Trade (TBT) is indirectly related with the issue. Certain standards known as the International Standards on Phytosanitary Measures (ISPMs) have been developed by the International Plant Protection Convention, an organization of the FAO. These standards are aimed to reduce arbitrariness by requiring countries to base their measures on scientific evidences and principles.

The major implications of the SPS Agreement are in the areas of developing pest risk analysis (PRA), fixing appropriate level of protection (ALP) and identifying disease/ pest free areas. Much of the desired information on nematodes in the areas still needs to be generated. In order to remain competitive in international trade apart from protecting agriculture and biodiversity following points need attention of our policy makers and plant protection experts in general and nematologists in particiular:

Legislation: There is need for a fresh look on Plant Quarantine Order 2003, which allows fruits, cut flowers, nuts etc freely for personal consumption upto 2 kg. Domestic quarantine regulations need to be in place for declaring certain nematodes as regulated non quarantine pests. The Nematological Society of India may send a proposal to PPA for declaring an official emergency control program for burrowing and potato cyst nematodes in the states where the nematodes have recently been reported and is spreading further.

Taxonomy: Classical taxonomy is a threatened field but indispensable for plant quarantine. At the same time interception of one or two nematodes or larvae along with the imported consignment can be identified only through molecular diagnostic protocols therefore capacity building for alien nematode pest identification is essentially required.

Survey and surveillances: Conducting nematode and region specific surveys/ surveillance and publishing status of occurrence of pine wilt, citrus burrowing, red-ring, testa, stem and bulb, foliar, soybean nematodes is mandatory under the rules. Surveillance for important plant parasitic nematodes, for a country like India is a huge task. Non-occurrence of certain highly pathogenic nematodes (pest free areas) may be confirmed and published to gain access to the international market.

Pest risk analysis: Assessment of risk must be based on scientific knowledge and expertise in the field, lot of which still needs to be generated for important plant nematodes e.g. stem and bulb nematode for onion and ornamental crops.

Databases: Compilation and analysis of the situation through databases on native nematodes, their host ranges and spread potential under different climatic conditions

need to be looked into. Nematode resistant crop varieties need to be registered, so that access to the information becomes easier.

Researchable issues: Projects shall be encouraged for funding on seed borne nematodes, biology of important alien nematodes which can follow the pathway, economic consequences of unintentional introduction of important nematode pests in prone areas, emergency provisions, national standards setting and their implementation.

The Doha Declaration of SPS offers challenges to gain new heights and opportunities for improving our knowledge on plant protection sciences. The challenges need to be faced with latest information, techniques, technology and expertise to convert them into opportunities for improved international trade. Economic gains generated through trade would definitely be shared plant protection disciplines by the private sector for their own sustenance in the competition. The country has sufficient trained manpower to take advantage of the new liberalized trade scenario. The Nematological Society of India should take leadership role in generating the much desired information on priority on issues which have emerged in the light of SPS Agreement of WTO.

Intellectual Property Rights and Its Relevance to Plant Nematology

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One of the major issues that have emerged with the advancement of scientific research is having the protection right of those inventions which are novel and/ or commercially viable. “Intellectual Property Rights” (IPR) are the rights granted by a state authority to the inventor to exclude others from imitating, manufacturing, using or selling a specific invention for commercial use during a certain period. The patent may be for a product, a process or both. In India both product-process patent in any field of technology are patentable, with certain exceptions.

Depending upon national laws, live forms may or may not be patentable. Process in plant protection discipline include methods for producing new microorganisms for enhancing biological utility, reducing pathogenicity in a plant and development of pesticides. The IPRs related to plant nematology would include all molecular and biotechnological techniques for identification, characterization, entmo-pathogenic nematodes/ fungal strains as bio-control agents, nematicide molecules, novel nematode detection and salvaging methods, culturing media/ techniques etc. Similarly the diagnostic tools/ kits, control measures are patentable. Further ‘use claim’ - like use of a biological strain to control pests is also recognized as a patent. *Trichoderma harzianum* and *Bacillus subtilis* based biopesticides and biofertilizers have been patented in US in two parts (a) process for preparation of novel growth media (b) new strain for nematode inhibitors.

In India “Patent Amendment Bill 2005” has been passed recently by the Parliament with a view to make IPR more meaningful. Among the biological innovations, patents are granted for microorganisms, gene sequences, novel substances with no previous recognized existence. Patentable processes include methods for producing new microorganisms, construction of new organisms by genetic recombination or cell fusion. Discovery of any living or non living substance, freely occurring in nature is not patentable; therefore new nematode species can not be registered. Nematode resistant plants - whole or any part there of other than micro

organisms are not patentable. Similarly biological processes for production or propagation, in agriculture are again not patentable.

Globally considerable disagreement exists with regard to the benefits of patenting of plant varieties, genes and agriculture as a whole. Advanced countries with high technological and financial capabilities favour patenting regimes in order to protect their commercial interests. On the other hand, developing countries with farm-based economies favour unrestricted accesses to new products. Poor countries argue for food security and enhancement of environmental health; and feel that profitable technologies should reach resource poor farmers without any price tag. To meet the demand, a program under public/ private sector linkages is working under the International Service for the Acquisitions of Agri-biotech Applications (ISAAA) which has various projects to facilitate transfer of technology to poor countries without bringing in the element of IPR.

Bio-agents for Nematode Management

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Plant parasitic nematodes inhabit many soil eco-systems and attack roots of large number of plants reducing their productivity substantially over a period of time. They are exposed to a wide range of natural enemies like bacteria, nematophagous fungi and predacious nematodes that are antagonistic to the plant parasitic nematodes. Intensive farming of agricultural crops and excessive chemicalization of agro- ecosystem with various agro-chemicals has affected the soil bio-diversity, adversely tilting the balance towards harmful soil flora and fauna. This deleterious alteration has increased the soil sickness in the absence of natural suppression by antagonistic and useful organisms called bio-control agents. This has led to the development new scenario where in many agricultural crops are affected by higher densities of nematodes and also the disease complex caused by pathogenic bacteria + nematodes and fungi + nematodes.

Researchers all over the world are engaged in standardizing the pest management strategies by following non-chemical and eco-friendly approaches such as cropping systems, botanicals and biological control agents. A strong movement to determine the potential of biological control agents in nematode management has occurred over the past several years.

Biological control aims at increasing the parasites, predators and antagonists of nematodes in the soil eco-system, in order to increase the mortality of plant parasitic nematodes leading to the biological suppression and development of suppressive soils in sustainable manner. This can be done by introductions and augmentation of the bio-control agents directly which would enhance the biotic component of environmental resistance.

Various researchers in the world investigated on the biological control of nematodes and documented the bio-efficacy of bio-control fungi such as *Paecilomyces lilacinus*, *Pochonia chlamydosporia, Trichoderma harzianum*, *T. viride, Arthrobotrys* spp., *Dactylella oviparasitica*, *Gliocladium virens*, bio-control bacteria such as *Pasteuria penetrans, Pseudomonas fluorescens Bacillus thuringiensis*, *B. subtilis, B. pumilis, Azatobacter chroococcum* and predacious nematodes such as *Seinura*, *Eudorylaimus, Mononchus* and *Odontopharynx* on various nematodes infecting agricultural crops.

In most of the cases of pragmatic approaches of a nematode disease management involves integration of several diverse control measures. In this context, biological control agents form an ideal component in the integrated nematode management systems (INMS) along with botanicals and to a limited extent chemicals.

Although most of the research findings of greenhouse and field experiments indicated that bio-control agents have the potential to significantly reduce the damage due to phytonematodes, but intensive investigations and large scale

demonstrations need to be carried out under field conditions to increase their adoption by the Indian farmer.

The soil environment is physically, chemically and biologically very complex. It varies in its characteristics and complexity both spatially and temporally. Biologically, it is most complex and the pace of interactions greatest around plant roots. Antagonists of nematodes occur in many groups of soil organisms and depending on the composition of these organisms in the soil or rhizosphere, the dynamics of the nematode population may be substantially buffered. The basic context of interactions among organisms is that each group is a food source for others, each group of organisms in the soil constitutes a source of required carbon and energy for those organisms feeding on it, the soil food web. Single bio-agent cannot be very effective in the management of disease complex. Further the bio-pesticide formulation containing single bio-gent cannot be active in different soil types, agro-climatic regions and on all the crops. Hence various researchers developed the management of these disease complexes by using more than one bio-control agent. They also developed protocols for the mass production of consortium of bio-agents. However, as of now there are guide lines for the registration of the single bio-agent based formulations in the country. As such, there is an urgent need for the formulation of guide lines for the registration of bio-agent - combination formulations in the country.

Advances in the techniques of biotechnology introduce additional possibilities of biological engineering of nematode antagonists. The strategy would involve selection or induction of variants of potential biological control agents with characteristics that enhance their effectiveness and rhizospheric competency. It is also required to develop the cultural practices that promote the growth of beneficial biota in the soil. Increased effectiveness might involve the introduction of an organism that is a more successful competitor, a more aggressive predator, a more virulent parasite or have enhanced survival characteristics. The approach may involve mutagenesis and screening or the direct insertion of genes for the desired characteristic into the genome of the organism. There is an important arena of basic and applied research opportunities in the genetic tailoring organisms for effectiveness in specific environmental and cultural situations. Rhizosphere bacteria that are natural colonists and inhabitants of the root surface and adjacent soil, appear to have many important, although little understood, properties. These bacteria may enhance plant growth or might suppress nematode populations by exerting an antibiotic effect. Additional research is needed to determine the organisms that are most effective and also to suggest methods for enhancing their activity in the soil. Such enhancement might include introducing the organisms into the soil at strategic intervals or introducing a food substrate to promote their activity.

The tactics of Introduction, Inundation, and Augmentation as biological controls of soil-inhabiting nematodes raise a series of implementation challenges. The development of biological control products faces several obstacles before a successful commercialization is achieved. The number of biocontrol products, successfully introduced into the market is still very low, but the actual requirement is very high. Evaluating the environmental effects and the fate of microbial agents is difficult, but should be attempted.

Beneficial Role of Nematodes in Soil and Plant Health

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Nematodes constitute one of the most important groups of organisms which inhabit the soil. They are highly diversified. Nematodes can be divided, rather arbitrarily, into parasitic and free-living forms. Nematode fauna play a significant role in regulating primary production, predation, energy transfer, decomposition of organic matter, and nutrient cycling in soil ecosystems. Biological insecticides have long been considered by many to be the viable alternative for pest management since they are economical, has long term control, without risk to human beings and other non-target organisms. Among insect parasitic nematodes, entomopathogenic nematodes-Steinernema and Heterorhabditis – with their respective bacterium complex have attained the status as potential biopesticides because of their impressive attributes. In India the work on these nematodes has gained momentum of late. Several species and isolates are known to be distributed throughout the Country. Efforts are underway to mass multiply, formulate and use in field for control of important insect pests. EPN possess specific biological and ecological features, which make their use in biological control exceptionally safe. The development of cost effective mass production technology and formulation led to the availability of nematode based products comparable with standard insecticides in the World market. The major constraints are their susceptibility to environmental extremes (temperature, desiccation, UV rays), scale up in mass production, lab adaptation, matching nematode and target insect, shelf-life of formulation under storage and transportation, application technology and field persistence. Nematode species/ strains must be matched against the insect groups they are best adapted to parasitize if control is to be achieved. EPN are used mostly in inundative biological control. Generally, it has been considered that EPN can be applied with conventional agricultural spray equipment. Considerations involved in the selection of an application system are volume, agitation system, pressure and recycling time, system environmental conditions, and spray distribution pattern. Differences in the application equipment components and their potential to damage EPN have been largely ignored with a few exceptions. An attempt is made to analyze the constraints and factors in developing EPN as potential bioagents. Studies have indicated that EPN have the potential to affect the diversity of native fauna in soil ecosystems even though they do not have any direct parasite/host or predator/prey relationship. EPN have also shown potential as antagonists to plant parasitic nematodes. Several greenhouse and field trials demonstrated the suppression of plant-parasitic nematodes by EPNs. This additional feature makes them more attractive. As indications are available of the mycotoxic and other effects they could very well be utilized for control of fungal and bacterial pathogens in soil. Nematodes are used as model systems for studying complex biological systems in diverse scientific fields such as genetics, development, nutrition, environmental toxicology, pharmacology, gerontology etc., Moreover as they are closely related to Coenorhabditis elegans , genetic manipulations would be much easier following the C.elegans model.

The free-living nematodes (bacterivorous, fungivorous and omnivorous species) are much less studied than the parasitic species. Soil nematodes play a significant role in decomposition of organic matter and nutrient cycling as many new areas are being discovered where the nematodes play a crucial role.

Nematode Management Strategies for Novel Farming Systems

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Farming is an ancient profession that is most likely to continue infinitely. Farming practices and cropping systems have evolved prompted by the changing skills, land, water, plant nutrient sources, agrochemicals and other resources and demands of the society. Various pests and diseases also evolved with these systems, resulting in natural selection of their species as well as of habitats and hosts. Plant parasitic nematodes occur wherever plants grow, but they attain endemic pest status in certain situations when long term availability of host crops, lack of extremes of abiotic factors, absence of natural enemies and infrequent disturbance. The need to feed the ever-increasing human population and industry/market needs have compelled monoculture, increasing nutrient availability, assured water, controlled environment and use of various agrochemicals have led to increasing selection and promotion of certain species of nematodes in specific cropping systems and situations.

The rice-wheat cropping system was designed to increase staple food grain production and to grow rice for export. This system caused reduction in the molya disease in parts of Rajasthan, Haryana and Punjab but has resulted in emergence of root-knot nematodes. Introduction of mungbean between wheat and rice and incorporation of its green stover has been found to reduce nematode population growth. The zero-tillage systems are now being increasingly advocated mainly to reduce energy and labour costs. Experiments have shown that the advantage would be short-lived since soil-borne pathogens including nematodes build-up within a couple of seasons.

Raised-bed planting systems are being designed for improving water use efficiency. This may also help in reducing the incidence of wilt and other diseases normally supported by high moisture levels. However, certain nematodes may become more serious under such systems, for instance the root-knot nematode was more serious in rice planted on raised beds compared to flat-beds.

Cotton-Chickpea cropping systems are now being advocated. Root-knot, reniform and root-lesions can become serious pests on both cotton and chickpea. Various intercropping systems are developed from time to time in which both the crops may serve as hosts of the same species of nematodes; in some cases a poor host may also suffer damage due to the increased populations on the more susceptible host crop. Due consideration to the nematode species and their population densities is essential before introducing a new cropping system.

Crop diversification is the need of the day both for enhancing farm income as well as for reducing the excessive nutrient mining and other deleterious effects on soil health. Introduction of more remunerative crops to replace the traditional cereals or inserting short duration crops during the short fallow periods between two main

crops are often planned. However, the possibilities of such changes increasing the population densities of certain plant parasitic nematode species need to be examined in advance.

The organic farming systems are now gaining popularity again after realization of the fertilizer and pesticide related environmental and health hazards. Indian agriculture had been chiefly organic almost till the middle of the 20th century. Application of organic matter to soil as compost, green manure or crop residues besides providing nutrients and improving soil structure also encourages natural enemies and suppresses plant parasitic nematodes. Selection of organic soil amendments, such as neem, karanj, mahua, calotropis, *Ipomoea, Parthenium* etc. with attributes of suppressing nematodes has found promising since 1970, however, the large quantities required have been a great limitation. Utilization of sulphur-containing crop residues, e.g. crucifer plant leaves, capable of liberating iso-thiocyanates after hydrolysis of their glucosinolates, may help in biofumigation. Biological control agents, especially nematophagous and parasitic fungi can be easily integrated with organic amendments. Due to the paucity of effective and cheap nematicides, most of the nematode management methods advocated are suitable for organic farming systems.

Precision farming systems involve site-specific applications of inputs in order to reduce variability and productions costs. Nematode infestations are typically patchy causing visible crop damage in a part of the field while the remaining remains unaffected. In early stage of infestation the patches are small but over the seasons these enlarge covering more area gradually. Demarcation of such patches in the previous season and effective treatment of the same and their peripheral areas can help in reducing the spread of the infestation to larger area as well as make considerable saving on not having to treat the entire field.

Environmentally protected horticultural systems have been practiced in temperate countries since long, but are being adopted in the subtropical and tropical regions to grow off-season crops, coordination with market demand, improve quality etc. The typical micro-agroclimatic conditions in protected horticultural systems, as in polyhouses, are most conducive to the establishment and growth of endemic nematode pests. The intensive cultivation on the same soil, almost continuous availability of host crops, good moisture and moderate warm temperature lead to rapid growth of the population densities of plant parasitic nematode species, especially the root-knot, reniform and root-lesion nematodes. Under open field conditions, these nematodes are less active in winter and peak summer, but in polyhouses they multiply fast and cause severe damage to susceptible vegetable and ornamental crops. By the time the damage becomes apparent, it is too late to take any control measures. The root-pathogenic fungi causing wilts and root-rot also become more serious if the plant root is injured by nematodes. The nematode management technology suitable for polyhouses would be different from that for the open field conditions.

Soil-less options, such as hydroponics and aeroponics, probably may not face nematode pests, but the solid medium systems like bag-culture, rock-wool culture, cocopeat etc. may support certain nematodes. However, high organic matter levels in such systems are also likely to support nematode antagonistic micro-organisms. Investigations on nematode behaviour in such systems are required

Use of plant tissue culture technology has enabled new cultivation systems in which large numbers of identical plantlets are produced, hardened and propagated. Transplanting such plantlets or of normally grown seedlings is gaining popularity in a

variety of crops including vegetables, fruits, ornamentals, sugarcane etc. However, nematode infestation in the soil used for hardening plantlets or raising seedlings can not only cause serious loss of plant vigour but also carry nematode infestation to other areas.

In peri-urban areas the cropping systems are characterized by market-driven production by mono-cropping, extremely high use of pesticides, excessive fertilizers and plant growth regulators. Urban effluents often worsen the scenario. Economic survival is dominant over ecological responsibility.

Kitchen gardens have been known to convince even non-believers of the importance of nematode pests. In large cities where land is scarce, roof-farming or terrace farming of vegetables, ornamentals and various medicinal and aromatic plants is now increasingly practiced. Nematodes soon emerge since the same soil is used for intensive cultivation over the years.

Nematologists have developed a variety of effective cultural, biological, physical and chemical methods for nematode management against most nematode pests and for most crops. Soil tillage systems, crop rotation, solar heat by summer ploughing or solarization using plastics, organic amendments, botanicals, biocontrol agents, resistant or tolerant crop varieties and reduced but targeted doses of nematicides have been the main components of nematode management. Their suitability and economics vary under different cropping systems, hence selection of the options is required.

Since individual methods do not suffice combinations of different methods need to be designed for specific cropping systems and economic situations. Greater efforts are required for development of resistant crop varieties, commercially viable formulations of botanicals and bio-control agents and safer nematicides. Since all nematode management methods are prophylactic in nature, understanding nematode population dynamics and development of forecasting models is necessary. Such models can also help in evaluating nematode related risk while designing new cropping systems.

In any cropping system the success of nematode management would greatly depend upon identification and realization of the gravity of nematode pest problem and adoption of a suitable package of practices. Creating awareness about nematodes and suitable management options for specific cropping systems are, therefore, essential.

New Approaches for Projecting Nematology *vis-a-vis* other Plant Protection Sciences

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Nematodes have been on the planet Earth for over 4 Billion years and would have been causing damage to crops for several millenia, however, Nematology, amongst the disciplines of plant protection is the youngest not only in India but also in the world. Still there are numerous countries where there is hardly any knowledge about nematodes. In fact, knowledge of nematodes and methods of their control can be historically correlated to the agricultural and overall prosperity of different nations, the USA, Germany, UK, erstwhile Russia, Japan, China, Australia and India, in that order, can be cited as examples. The poor recognition to nematology has of course been mainly due to the subterranean habitat, small size, non-spectacular slow damage, mostly non-specific symptoms and difficulties in their management. The farmers seldom make noise about nematode damage, even if they see it, they confuse it for other causes. Even many extension workers are ignorant about nematodes. It is much more difficult to convince the farmers, administrators, policy-makers and even fellow scientists in other disciplines that nematodes are important pests. The nematode management technology has been largely based on cultural practices, which is ideal for environment, easy to adopt by the farmers and very effective and economical, however, these familiar practices fail to impress the farmer and public who are more easily attracted to more fanciful chemical and to some extent biological methods. The nematologists themselves bay and large have been rather silent and non-assertive workers often subdued in the presence of large number of entomologists and plant pathologists who are more often approached by the farmer about the visible pest organisms and obvious symptoms of damage. A leaf half cut by an insect or blotched due to a fungus or bacteria or twisted by a virus is much more obvious than many full leaves that have failed to appear due to the numerous nematodes unseen underground. Plant Nematology, by definition, has also been limited to nematode pests and their management, whereas nematodes do have other roles in agriculture.

Creating awareness about the nematodes and their economic importance both of pest species and the useful ones is the most important. Further, projecting the modern scientific methodology involved in nematological research needs projection. For creating awareness (i) more effective use of the mass media - print, radio, TV and internet and (ii) involvement of KVKs, extension workers and farmers in demonstrations is required. A small chapter on nematodes as pests of crops and parasites of man and cattle at the junior school and high school level can do wonders. Most agricultural graduates lack knowledge of nematodes since their universities do not give even the bare minimum one credit course on nematodes. A few lectures with the non-insect pests fail to sensitize the student. Special training courses need to be organized for extension specialists. Post-graduates trained in nematology are a must as subject matter specialists at some of the KVKs in regions with serious nematode problems in each state. Both for farmers and students more animated and dramatic presentation of nematodes is required than the still pictures. Small but effectively worded bulletins and handouts with prominent pictures need to be developed in all languages. Small documentary and advisory Videofilms on nematodes should be developed in all languages and used for broadcasting, training,

teaching and extension programmes. The same should also be provided through web-based extension programmes. The role of nematodes as important incitors and aggravators of disease complexes needs to be highlighted. Since nematode populations and their damage potential are greatly related to cropping systems and agronomic practices, the agronomists should be apprised of the importance of prior analysis of the likely impact on nematodes while planning newer techniques of management of soil, nutrients and water as well as while designing new cropping systems and crop diversification.

There also a need for projecting nematology as a modern science. The knowledge of the nematode genome sequence has been used more in various other medical and agricultural sciences but hardly in nematology! We need to utilize this knowledge for understanding nematode-plant relations, resistance mechanism and markers, survival, susceptibility to biocontrol agents etc. Modern scientific methods can be used for mass culture and formulations, understanding the chemistry of nematicidal products and molecules etc. There is a need for more basic research in development of techniques for detection, identification and management of nematodes. Research is also required to use nematodes as bioindicators in environmental studies, especially in pollution monitoring and understanding the impacts of global climate change on soil biota.

Quarantine regulations have been important in preventing the entry and spread of nematode pests including nematodes. Nematodes present in the country as well as those not so far present are now even more important in international trade to meet the requirements of sanitary and phyto-sanitary regulations in the post-GATT scenario. Nematodes can be important organisms in non-tariff trade barriers. Even after 40 years of nematology in India, we lack sufficient documentation on the distribution of nematodes and most of our ports of entry do not have trained nematologists. This importance of nematodes and need to detect them also needs emphasis.

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