National Seminar

on

Nematological Research in India

Challenges and Preparedness for the New Millennium

17 December, 1999

Chandra Sekhar Azad University of Agriculture and Technology
Kanpur-208 002

Nematological Society of India

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D.O.No.SECY. (DARE) & DG, ICAR/99/ 1362
December 06, 1999

Dear Dr Gaur,

Kindly refer to your letter of 30th November, 1999 inviting me to participate in the National Seminar on 'Nematological Research in India: Challenges and Preparedness for the New Millennium' to be held on 17th December, 1999 at CSAUA&T, Kanpur.

Since I would be participating in the KVK Workshop to be chaired by the Minister of State for Agriculture at Hyderabad on that day, I deeply regret that it would not be possible for me to participate in the aforesaid National Seminar, although I would have very much liked to do so. However, I take this opportunity to convey my best wishes for the success of the National Seminar and look forward to receiving the recommendations of the same.

With kind regards,

Yours sincerely,

(R.S. PARODA)

Dr H.S.Gaur,
Organising Secretary, National Seminar &
General Secretary,
Nematological Society of India,
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Indian Agricultural Research Institute,
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NATIONAL SEMINAR ON NEMATOLOGICAL RESEARCH IN INDIA
Challenges and Preparedness for the New Millennium
17 December,1999 at CSAUAT, Kanpur

PROGRAMME

8:30-9:30	REGISTRATION
9:30-10:30	INAUGURATION
10:30-10:45	TEA
10:45--11:45	SESSION I
Chairman:	Dr. Gopal Swarup Co-chairman : Dr. Pramilla Gupta
Rapporteurs :	Dr. M.S. Sheela, Dr. Pankaj
Speaker:	Dr. H.K. BAJAJ
Topic :	**Systematics and biodiversity of nematodes**
Speaker :	Dr. A.K. GANGULY
Topic :	**Application of molecular biology in Nematology**
11:45--12:45	SESSION II
Chairman:	Dr. B.S.Yadav Co-chairman : Dr. I.J. Paruthi
Rapporteurs:	Dr. Aruna Parihar, Dr. H.K.Sharma
Speaker :	Dr.H.S. GAUR
Topic :	**Basic and applied nematode ecology**
Speaker :	Dr. V. K. KAUL
Topic :	**Nematode management in food crops**
12:45-14:00	LUNCH
14:00-15:00	POSTER SESSION
Chairman :	Dr. . K. Krishanappa Co-chairman : Dr. K. D. Upadhyay
Rapporteurs:	Dr. Anil Sirohi, Dr. Anju Seth
15:00-15:15	TEA
15:15-16:15	SESSION IV
Chairman:	Dr. C.V. Sivakumar Co-chairman : Dr. R.V.Singh
Rapporteurs:	Dr. Kusum Dwivedi, Dr. S. Lingaraju
Speaker :	Dr. P.P. REDDY
Topic :	**Integrated nematode management in commercial crops**
Speaker :	Dr.A.C. VERMA
Topic :	**Nematode problems in Indian gooseberry (Aonla)**
16:15-17:15	SESSION V
Chairman:	Dr. J.S.Gill Co-chairman : Dr. K. V. Ramana
Rapporteurs:	Dr. M.S. Rao, Dr. Anju Kamra
Speaker :	Dr. D.J. PATEL,
Topic :	**Transfer of nematode management techniques to farmers' fields**
Speaker :	Dr. S. RAY
Topic :	**Nematological teaching in India**
17:30-18:30	EXECUTIVE COUNCIL MEETING

CONTENTS

INVITED LECTURES

Application of Molecular Biology in Nematology

A.K. GANGULY and UMA RAO
Division of Nematology, I. A. R. I., New Delhi-110 012

Molecular biology is of immense value to unravel intriguing plant nematode interactions and to resolve confusion in nematode identification and phylogeny. Thus research on molecular aspects of plants nematode interactions has attracted both nematologist and molecular biologist mainly because of three reasons, (I) ability of phytonematodes to modify the host morphology and physiology resulting in the formation of feeding sites through which the sedentary nematodes derive their nutrition, (ii) prospects for exploitation of natural Resistance in nematode management and (iii) requirement of reliable and stable parameters for identification in addition to morphological characters. There are several approaches for designing nematode resistant cultivars. One such approach is the exploitation of natural resistance genes (R-gene). Cloning and characterization of the first R-gene against *Heterodera schachtii* has been done by Cai et. al. 1997. Cloning and molecular characterization of nematode resistant genes is a pre-requisite to the development of transgenic crops. Alternatively antifeeding structure approaches specific to sedentary endoparasites aim to destroy the nutrient supply by expressing the nematicidal gene product. The main advantage of this approach is high durability since nematode cannot influence the resistance conferring process. Further, the anti nematode gene products are toxic to only nematodes but not to the host plant and to animals/humans who consume the plant or its products. Several class of potential antinematode genes encoding lectines, enzymes and proteinase inhibitors are being evaluated for their ability to confer broad spectrum nematode resistance. Gene pyramiding is almost certainly going to be an important to increase field durability and to widen the spectrum of Nematode controlled by any one transgenic line. The base sequence of DNA is the primary source of biological variation and thus nucleic acid analysis should provide the ultimate to the identification of individuals. Further molecular markers have assisted in solving the uncertainities in tracing the phylogeny of nematodes due to lack of fossil records. The development of the molecular marker technique has led to a new application which shortens the breeding process _ the marker assisted selection. Markers that are tightly linked to a trait of interest can be used to search for plants carrying this marker, thus individual plants are already selectable within population before the phenotype of the special trait will be expresse. Lastly, molecular marker aided resistance selection and its application in breeding for nematode resistance is of great importance. The desirable genotype carrying the gene of interest now can be identified at the seedling stage in a large segregating population. Thus current advances in molecular techniques combined with intensive efforts devoted to study the plant nematode interactions will certainly lead to development of alternative methods for nematode control.

Systematics and Biodiversity of Nematodes

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Pioneer taxonomic research conducted by Siddiqi, Jairajpuri, Das and Khan during 1959-65 had brought Indian Nematology on the international map and laid the sound and stable foundation for the all round growth and development of Nematology in India. However, tempo has slightly slowed down in the recent years. Till date only 640 species of tylenchids, 78 of aphelenchids, 72 of longidorids and 8 of trichodorids have been recorded from a vast country like India that supports diverse flora of more than 45,000 plant species. Concrete efforts are needed to explore nematodes of aerial plant parts and endo-, semiendo- parasites of roots. There is no dearth of expertise in the country that should be fully utilized. To remain at par excellence with advanced countries light microscopic observations have to be supplemented with scanning electron microscopic studies for which facilities should be developed in the ICAR institutes and SAUs. National Nematode Collection of India, I.A.R.I. New Delhi, Zoological Survey of India, Calcutta, Aligarh Muslim University, Aligarh and CCS Haryana Agricultural University, Hisar should be strengthened with type material and identified slides besides regular exchange of material. To cater the needs of applied nematologists National Identification Net work may be created which should facilitate identification of species and races; maintain pure culture of specified species/races of important pests *in vitro* and *in vivo*, supply them to other nematological centers; and organize refresher courses. All the SAUs should also be encouraged to take up taxonomic studies on their own. A taxonomic course of at least 3+2 credits with emphasis on practical work is a must for Postgraduate curriculum in Nematology. Conventional taxonomic methods are likely to continue as a major tool of identification but taxonomists should keep themselves updated with the non-traditional approaches e.g., biochemical, immunological, numerical, etc.) and use them wherever feasible, especially for discrimination of closely related species/ races of important pests. In this era when emphasis is on non chemical methods of management like crop rotation, use of resistant/ tolerant varieties, biocontrol etc. which are highly specific, taxonomic research will have to be fully integrated with applied aspects of Nematology.

Fundamental and Applied Ecological Research in Indian Nematology

H. S. GAUR

Division of Nematology, Indian Agricultural Research Institute, New Delhi-110 012

The evolution of plant parasitism in nematodes, their abundance and their attainment of pest status of in a given agricultural or other plantation system are the manifestations of the interrelationships with a vast array of abiotic and biotic components of their micro- and macro-environment. Thorough understanding of the intricacies of such relationships as influence the distribution, survival, activity, population dynamics, host invasion, pathogenicity, development and reproduction and crop damage is a prerequisite for exploiting nematodes as biological models or as bio-regulators of other organisms and for devising effective nematode management schedules.

A large number of studies have been carried out in India to study the distribution, population behaviour, interaction with other pathogens, predatory behaviour, survival and relationships between population density and crop growth, sometimes yield. Valuable, though far from complete, information has become available on these aspects. The effects of temperature on nematode survival and population growth have been used in developing nematode management methods. Most nematologists in India have taken part in some limited aspects of ecological research. However, the scenario of ecological research in the country has been rather incomplete and far from being holistic. The inadequacy of knowledge about the population dynamics of key nematode pests in the major cropping systems in the different agroclimatic zones is still lamented. Very little has been done to analyse and evaluate the influences of the driving environmental variables. We still do not have many standard Indian models to boast of. We still have not exploited the potential of computer application to ecological data; the modern biochemical, molecular, and electro-physiological have yet to be applied to nematode ecological research in the world in general and India in particular.

The teaching of nematode ecology is carried out at almost all the institutions teaching nematology but, barring at a few well developed centres, it has been rather elementary. It is often limited to introducing the biotic and abiotic factors, terminology of survival mechanisms, population behaviour and inoculum density – crop growth/ yield relationships. The result is that the alumni carry an impression that ecology is an old-fashioned science without realising the exciting intricacies of the interrelationships, the scope for use of most modern of physical, chemical, biological and agronomical technology. The utility of ecological research in providing practically feasible, environmentally safer and economical integrated nematode management technology suitable for our farming scenario, especially when we lack specific nematicides, acceptable resistant varieties are rare and very potent mass-culturable bio-control agents still remain a dream.

We enter the new millennium much better equipped with knowledge of nematode ecology and the realisation of its importance than we were during even the last century of the current millennium. We now know our vital knowledge gaps and hope to be able to fill many of them with more in-depth and organised ecological research and teaching. A number of newer line of research on environmental adaptations of nematodes with the objectives to curb or promote them as per needs are likely to be opened using modern equipment, methodologies and algorithms.

Nematode Management in Food Crops

V. K. Kaul
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To keep pace or stay much ahead of future food demand is a collosal task. One way to increase productivity is to plug the yield losses due to pests and diseases. Estimates of overall annual yield losses due to palnt parasitic nematodes are around 12% but range as high as 19.7% in the most economically important genus *Meloidogyne* (Sasser & Frekman, 1987). Though Nematology owes its speady development to the development of nematicides, but the environmental pollution and the damage caused coupled with human health hazards, non availability and economics have made these chemicals of little choice in nematode management. In India or in areas of low input agriculture, chemical control has never been a viable economic opinion. The various forms of alternative agriculture systems which currently include low external input and traditional techniques such as multiple cropping, crop live stock integration, integrated pest and nutrient management is a global scenario, whereas shift in cropping pattern e.g. rice-wheat system whch occupies 10.5 m ha, vast – semi araids, crops begin grown in succession, degradation of soil health in relation to depletion of organic manure and nutrients, salinization, destruction of soil physical properties, persistance of weeds are bound to add new dimensions to the nematode problem. Whilst there are problems that are of concern or priority in developed countries, many of the problems are as much ours as of others. Current research on nematode management is centred on the production of resistant cultivars and the development of biocontrol agents for use in sustainable agriculture systems, pest management schemes integrating crop rotation with cultural practices including non or poor hosts, resistant cultivars, biological control agents and also on characterisation and quantification of the nematode population thresholds from the stand point of the control. The advent of biotechnology and molecular biology now offers a number of new approaches to biochemical identification of pest and development of disease resistant varieties.

In India, the nematode management programmes based on management of nematodes in nursery, resistance, exclusion, sanitation, crop rotation application of organic amendments, use of botanical antagonists and overall integrating management tactics with crop husbandry are the options. An interdisciplinary approach is beneficial towards more complex understanding of the problem from a judicious perspective. We need a holistic vision to tackle this problem. Nematological Society of India has a major role to play in articulating the aspirations of the Nematologists and farming community in crossing over the narrow confines of the discipline and participate with other partners of crop productivity viz. Agronomy, Soil Science, Entomology and Plant Pathology and chalk out concrete location specific strategies, programme or experiments through AICRP on Nematodes. But no less is the role of individual Nematologist and other interdiscipline related persons in such a participation.

Integrated Nematode Management in Commercial Crops

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Division of Entomology and Nematology, Indian Institute of Horticultural Research, Hessarghatta Lake (P.O.) Bangalore-560 089

Of late, intensive cultivation of commercial crops is gaining importance because of their increasing value in exports and domestic markets. Monocropping of these crops increased the nematode populations to an alarming dimensions. Plant parasitic nematodes have become one of the major limiting factors in commercial crop production systems.

Root-knot nematode (*Meloidogyne* spp.) are serious pests of various fruit crops (papaya, acid lime and banana), vegetable crops (tomato, egg plant, okra, onion, carrot, cowpea, french beans, peas, cabbage, cauliflower and cucurbits), ornamentals (tuberose, carnations, gerbera, crossandra, asters, chrysanthemum, gladiolus etc.) and cash crops (cotton and tobacco)

Reniform nematode (*Rotylenchulus reniformis*) is another important nematode inflicting considerable losses in the yield of many vegetables, fruit ,ornamentals and cash crops. Citrus nematode (*Tylenchulus semipenetrans*), burrowing nematode (*Radopholus similis*) and lesion nematode (*Pratylenchus* spp.), dagger nematode (*Xiphinema* spp.) do cause considerable amount of damage to the various commercial crops. The nematode problems in the commercial crops are widespread, almost in all the production system followed by all the categories of farmers.

To mitigate the losses caused by nematodes it becomes invariable to depend on the chemicals. However, nursery bed treatment, seed treatment, seedling treatment and judicious use of nematicides under the field conditions would help in the management of nematodes. By and large due to lack of insight by many farmers and cost of chemicals, the judicious use of nematicides has not taken place under Indian conditions. The hazards associated with the use of chemicals and problems in resistance breeding made the nematologist to research for alternative methods of nematode management and combining these alternative methods to evolve Integrated Nematode Management (INM) strategies. In INM strategies like trap crop technology, crop rotations, cover crops, solarisation, use of botanicals such as neem, castor, karanj and mahua cakes, etc., use of biocontrol agents, endomycorrhiza are important. Some of these components of management were already integrated to develop the INM strategies. However, standardization of methods for effective utilization of biocontrol agents is very important for evolving sound integrated nematode management strategies. The role of most important bacterial (*Bacillus thuringensis*, *Azotobactor chrococum*, *Pasteuria penetrans*, *Pseudomonas fluorescens* and *Streptomyces avermitilis*) and fungal (*Paecilomyces lilacinus*, *Verticicillium chlamydosporium*, *V. lecanii*, *Trichoderma harzianum*, *T. viride*, *Arthrobotrys conoides*, *Gliocladium virens*, *Glomus mosseae*, *G. fasciculatum*, *G. epigaeus* and *G. deserticola*) antagonists in biological suppression of plant parasitic nematodes will be discussed. The priority areas of research which require immediate attention will also be discussed.

Nematology Teaching In India

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Growth of Nematology, more precisely agro-nematology in the world has been phenomenal during the current century which is poised to touch the new millennium a few days from now. We in India have not lagged for behind. India at present is recognized as a leading country in the world in nematological research and education. In fact India's ancient history bears ample testimony of intensive research on human nematode parasites called 'Krmi' in Sanskrit and their management and discourses on the subject in the 'Ashramic' schools as per information contained in the Rig, Jajur and Atharva Vedas dating back to 6000-4000 BC (Ray, 1986; 1992). In modern times, though organized nematological research in the west started around the middle of the nineteenth century following the discovery By Berkeley of the first root-knot nematode in England in 1855 as against the first plant parasitic nematode which again was a root-knot nematode reported from India in 1901 (Barber, 1901), institutionalized teaching programmes in nematology started almost simultaneously both in the West and in India during the nineteen sixties and seventies. Foundation for the nematological teaching in India was laid with the organisation of an International Nematology course training at IARI in 1966 followed by seventh South East Asia Postgraduate Nematology course training between 1967 and 1979 and induction of nematology teaching courses in the State Agricultural Universities (SAUs) during the same period. Out of the 28 SAUs of the country as many as 15 SAUs and also the 'deemed' university IARI are offering courses in nematology either at U.G. or at P.G. or at both levels. The first independent department in nematology was established at IARI in 1966 which started P.G teaching from 1969. Full-fledged departments of nematology have been created in some of the SAUs like OUAT, Bhubaneswar (1971), GAU, Anand (1975), HAU, Hisar (1977), MSU, Udaipur (1977), TNAU, Coimbatore (1980), NDUAT, Faizabad (1981), KAU, Vellayani and RAU, Pusa (1982) and AAU, Jorhat (1983). In 12 SAUs about 1800 students in the U.G. level are exposed to introductory courses in nematology every year covering 2 to 6 credit hours. Facilities for P.G. level specialization are available in 14 SAUs and also at IARI with the capacity of over 100 students for Master's degree and 30 students for doctoral degree. These figures are likely to vary marginally if we take into account the actual entry and pass outs in these universities and also the limited teaching programmes in nematology present in some of the leading traditional Universities like the Punjab University, Chandigarh, Aligarh Muslim University, Aligarh, Banaras Hindu University, Banaras etc.

However, the interest and expectation generated during the seventies and eighties seems to be fading away and the discipline seems to be losing its glamour due to several reasons such as (1) inadequate credit share at U.G. level for Nematology, (2) non-uniform credit load as well as course contents at P.G. levels, (3) extremely weak practical training and field problem exposure both at U.G. and P.G. levels, (4) total absence of technology transfer programme, (5) inadequate in-servce training and faculty competency improvement programmes, (6) unbalanced and root-knot-centric applied research in total negligence to research on other nematodes as well as fundamental research, (7) lack of inter-disciplinary collaborative research (8 inadequate funding for

teaching, (9) lack of employment opportunity for the pass outs and finally (10) lack of an unified efforts to further the interest of the discipline at different levels.

There is urgent need to look into these deficiencies if nematology in the country is to attain new plateau of excellence and maintain a steady progress in the interest of the discipline and service to the nation.

Transfer of Nematode Management techniques to Farmers Fields

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In India, research on phytonematodes got momentum during last 3-4 decades. Now they have become a serious threats to successful and profitable cultivation of almost all agricultural crops in the country. Twenty three nematode spcies belonging to major genera viz. *Meloidogyne, Radopholus, Pratylenchus, Heterodera, Rotylenchulus, Tylenchorhynchus, Hoplolaimus, Helicotylenchus,* etc. are identified as important, causing 7.2 to 100% loss in several cash and life sustaining crops in India. For their management, several practices viz. cultural, deep ploughing, plastic tarping in summer, rabbing, crop rotation, identification of resistance sources, use of botanicals, organic amendments like neem, mustard and caster cakes, poultry manure,pressmud and biological suppression using parasitic fungi and bacateria as well as chemical nematicides remained important tools in the present century.

Out of these practices, non chemical strategies are intensified for sustainable agriculture as low input technology, exploitation of natural resources, easy integration with other management systems which are now proved safe, economic and effective for suppression of phytonematodes in various agricultural crops: Biological suppression of root-knot and cyst nematodes is also successfully demonstrated under laboratory conditions during last decade. Several crop rotations are also identified for nematode management. Rabbing and soil solarization using plastic tarping in nursery beds during summer are the best methods for root-knot nematode management in nurseries. These technologies are also successfully demonstrated to farming community through farmers meetings and agricultural fairs. The progress made in 20th century for nematode management is quite satisfactory but looking to new horizons, more tools are required to be urgently implemented in India. Scopes are there to promote bio-nematicides as alternative to chemicals and in integrated nematode management. Knowledge of biochemical tool and genetic engineering now becomes essential for crop improvement and preparing transgenic plants for nematode management in few agricultural crops attacked by one or two nematodes e.g. reniform nematode in castor and banana, cereal cyst nematode and earcockle nematode in wheat and so on.

These proven nematode management techniques are now required to be demonstrated on farmers fields through extension machineries effectively to make awareness and to adopt by farmers in order to manage nematode multiplication and spread and thereby to enhance crop production.

Nematodes associated With Indian Gooseberry (*Aonia*) *Emblica officinalis* Gertn.

A. C. VERMA
N. D. University of Technology, Kumarganj, Faizabad

Aonla (*Emblica officinates* Gertn.) a minor fruit crop has great significance in Indian Ayurvedic Medicines. It is one of the important high value medicinal crops of India mostly grown in U.P. where this fruit is originally cultivated in Pratapgarh district. Among the various factors responsible for its low yield and poor growth the problem of phyto_feeding nematode has often been reported from different parts of India. The present investigation has been undertaken to find out the association of various plant parasitic nematodes in different aonla nurseries of the districts Faizabad, Sultanpur and Pratapgarh. Ninety-three soil samples were collected from various *Aonla* nurseries of districts Faizabad, Sultanpur and Pratapgarh during August and September 1998. The nematodes were extracted from the soil samples by processing through the Cobb's sieving and decantation technique. Eight species of nematodes viz. *Hoplolaimus indicus, Tylenchorhynchus vulgaris*; *Pratylenchus sp., Helicotylenchus indicus; Paratylenchus sp., Rotylenchulus reniformis; Trichodorus sp. and Meloidogyne sp.* were detected from the samples. Out of these *Helicotylenchus indicus* was detected from almost all the samples. It was the most dominant one with the population of 73-530 per 250 cm^3 soil. The association of spiral nematode, *Helicotylenchus indicus* with *Aonla* has been reported for the first time.

Systematics, Pathogenicity and Basic Research

Interrelationships Among the Twelve Indian Populations of Root-Knot Nematodes, *Meloidogyne* spp.

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[1]Department of Nematology, Orissa University of Agriculture and Technology, Bhubaneswar

A systematic study of root-knot nematodes (*Meloidogyne* spp.) was conducted using 12 populations collected from different states of India. Five populations (Delhi, Gujarat Haryana, Rajasthan and Tamil Nadu) were identified as *M. javanica*; three populations (Delhi, Maharashtra and Orissa) as *M. incognita*: one population each from J & K and himachal Pradesh, as *M. arenaria* and *M. hapla*, respectively. While, two populations, one each from Kerala and Uttar Pradesh could not be assigned to any of the known species of *Meloidogyne*. Clustering of these populations was done on the basis of 15 morphometric characters of mature females and 22 of second stage juveniles (J_2), separately. The resultant two phenetic dendrograms for J_2 and mature females grouped the populations into six and five clusters, respectively, with some variations in the position of populations in different clusters. In both the dendrograms, *M. arenaria* showed closer relationships with *M.javanica* than *M. incognita*, whereas *M. hapla* was more close to *M. arenaria*. The two populations of undescribed species from Kerala and Uttar Pradesh showed greater affinities with *M. javanica* and *M. incognita*, respectively. Based on J_2, Delhi and Orissa populations of *M. incognita* were found far away from Maharashtra population of this species.This was mainly attributed to the influence of 5 morphometric characters (L, DGO, O %, c' and body width) which contributed nearly 64.2 % for clustering. The mean values for these characters in Delhi and Orissa populations were significantly higher than that of Maharashtra population, which was therefore designated as variant of *M. incognita*.

Morphobiometrics of Two Geographical Populations of Reniform Nematode, *Rotylenchulus reniformis* from India

G. M. V. PRASADA RAO and SUDERSHAN GANGULY
Division of Nematology, Indian Agricultural research Institute, New Delhi – 110012

Morphobiometrics of two geographical populations of reniform nematode, *Rotylenchulus reniformis*, collected from Delhi and Andhra Pradesh (AP) states of India, were studied. A detailed study of 17 morphometric and allometric characters of young females, revealed large but gradual and continuous variations in the range values for most of the characters, thus indicating the two populations to be 'clines' of this species. The populations exhibited notable differences in the mean values of L, body width, distance from anterior end upto oesophageal gland lobe, position of vulva, DGO and O %. The

ratios a, b', c and c' were found to be highly variable and their CV values were also higher than those of their respective linear characters which also did not have any significant correlation. These ratios were not found valid and justified in both the populations. The ratio V was found to be the least variable since its CV value did not exceed 5.9 %, which was less than that of its linear characters – body length and distance from head to vulva. Its linear characters exhibited allometric growth only in AP-population, which was evident from the significant correlation coefficient (r). Unlike V %, O% exhibited high variability (11.5 – 18.9 %) which was higher than that of its linear characters. Still, it was found to be valid due to significant correlation between its linear characters in Delhi – population, but not in AP – population. The two populations were thus found to be distinct morphological variants of *R. reniformis*.

Effect of *Rotylenchulus reniformis* on Phenylalanine Ammonia Lyase (PAL) and Peroxidase (PO) activity in cotton

ANIL SIROHI, PANKAJ and A.K. GANGULY
Division of Nematology, Indian Agricultural Research Institute, New Delhi

The reniform nematode, *Rotylenchulus reniformis* is one of the major nematode problems of cotton in India. The main objective of present study was to search for a biochemical marker for the prediction of resistance in cotton at an early stage of crop growth against *R. reniformis*. Enhanced phenyl ammonia lyase (PAL) and peroxidase (PO) activity in roots of all the seventeen cultivars/lines inoculated with *R. reniformis* (3 infective stage juveniles/g of soil) was observed after 48 h of inoculation compared to check. The PAL activity increased by 10 to 74% and PO by 13 to 81% in roots of infected plants. Cultivars showing higher PAL and PO activity change supported lower final population of nematode, indicating resistance.

Nematodes associated with Banana Rhizosphere in different Cropping Systems in Kerala

JIJI, T., SHEELA M.S. and PREMILA, K.S.
College of Agriculture, Kerala Agricultural University, Vellayani, Thiruvananthapuram

Seven genera of plant parasitic nematodes *viz.*, *Radopholus similis*, *Heterodera oryzicola*, *Helicotylenchus multicinctus*, *Pratylenchus* sp., *Meloidogyne incognita*, *Hoplolaimus indicus* and *Criconemoides* sp. were found in the rhizosphere of banana in diffferent crop combinations like coconut + banana, coconut + pepper + banana, coconut + pepper + banana + vegetables and banana alone. Survey revealed that *R. similis* was the widely distributed species, followed by *H. oryzicola*. The population of *R. similis* was maximum in crop combinations having coconut and pepper. The population of *H. oryzicola* was the maximum in reclaimed paddy field having banana alone. Heavy populations of *M. incognita* was observed in banana planted along with vegetables in

reclaimed paddy fields. Among the different varieties, Nendran variety of banana was highly susceptible to *H. oryzicola*. Palayamkodan was comparatively less susceptible to *H. oryzicola*. In *R. similis* the varietal preference was not observed. The proportional build up of different nematodes in various crop combinations and soil types, were also studied.

Pathogenicity of Lesion Nematode, *Pratylenchus zeae* on Maize cv. Farm Sameri

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Study on pathogenicity of lesion nematode, *Pratylenchus zeae* to determine threshold level in maize cv. Farm Sameri indicated that an inoculum level of 1,000 and above nematodes/plant significantly decreased plant height, fresh shoot and root weights. Soil, root and total nematode population build up/plant progressively increased with an increase in nematode inoculum levels from 0 to 10,000 nematodes/plant. Nematode reproduction rate decreased with an increase in inoculum levels. It was maximum of 66.00 times in the level of 10 nematodes/plant and minimum of 5.50 times in the level of 10,000 nematodes/plant. Uptake of various nutrients viz., nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S) significantly reduced from the level of 500 to 10,000 nematodes/plant except P which significantly reduced from the levels of 1,000 to 10,000 nematodes/plant. Control (uninoculated) plants had significantly more uptake of all the nutrients over other treatments.

Effect of Root-Knot Nematodes, *Meloidogyne incognita* and *M. javanica* Pathotype-1 on Physical Status of Banana

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The root-knot nematodes, Meloidogyne spp. are predominant and causing 20.60 % yield loss in banana in Gujarat. Present study was carried out to know the effect of Mi and Mj pt.1 infection on meteorological parameters in banana cv. Basrai. Tissue cultured banana plants raised in pots were inoculated @ 100, 1,000, 5,000, 10,000, 50,000 and 1,00,000 J2 of Meloidogyne incognita and Meloidogyne javanica pt.1 /plant separately with check. Leaf temperature and transpiration rate increased as inoculum level increased and it was significantly higher in plants inoculated with 1,00,000 J2 of M. incognita or M. javanica pt.1/plant over other treatments. Diffusion resistance rate showed negative relationship with level of inoculum.

Interaction Between *Meloidogyne Incognita* and wilt Inducing Fungus *Fusarium oxysporum* f. sp. *ciceri* on Chickpea

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Interaction of *Fusarium oxysporum* f. sp. *ciceri* (Foc) and *Meloidogyne incognita (Mi)* on chickpea cv. Dahod Yellow revealed that the organisms either individually or in combinations reduced plant height and fresh shoot and root weights significantly but the reduction was more by Mi as compared to Foc. Among combined inoculations of nematodes and fungus, simultaneous inoculation of both the pathogens had maximum suppressive effect on growth of chickpea plants as compared to preceding or succeeding inoculations of fungus and nematodes. Root galling and nematode multiplication on chickpea were maximum when nematodes were inoculated alone, but it was reduced in the presence of fungus. The fungus alone was able to produce wilt disease but the incubation period for disease development and severity of the disease increased when root-knot nematodes were present with fungus. Maximum wilting of plants was observed when the fungus and nematodes were inoculated simultaneously followed by fungus inoculation 2 weeks after nematode inoculation and nematode inoculation 2 weeks after fungus inoculation.

Association of Mite with *Meloidogyne javanica* infested Roots of Grapevine

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Association of mites belonging to family Acaridae was detected with roots of grapevine (*Vitis vinifera*) var. perlette. The grapevine roots collected from 6-7 year-old established orchard having root knot nematode, *Meloidogyne javanica* infestation. The root galls developed by these root knot nematode harbour mites and its eggs of different stages of development. Mites and their eggs were also found in the cortical region of roots. The exact location of occurrence of mites in the root system was found restricted to root galls, with and without root knot nematode, and its surrounding area. The number of females and eggs of root knot nematode were scanty in the galls harbouring mites. The mites probably reached the root gall by cutting holes in epidermis adjacent to galls and moved through cortex. It may be predicted that the presence of mites may have influence on nematode.

Seasonal Pathogenic Variations of Root-Knot Nematode *Meloidogyne Incognita* in Brijnal

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The seasonal variations in pathogenic effects of *Meloidogyne incognita* in brinjal in 4 crop seasons viz. July – August; October – November; November – February; and February – April were studied in green house by inoculating *M. incognita* juveniles at 5 levels viz 250, 500, 1000, 2000 and 4000 juveniles/seedling. The threshold level of damage at which significant reduction in various growth parameters occurred was 250 juveniles/750 cc soil in July – Aug. and Feb. – April, 1000 J2 in Oct. – Nov. and 500 J2 in Nov. – Feb. crop season. The reduction of plant height was most in July – August season followed by Feb. – April; Nov. – Feb. and least in Oct. – Nov. crop season. The number of galls, eggmasses, eggs and juveniles was maximum at 2000 juveniles inoculum level in July – Aug. and Feb. April crop season while it was maximum at 4000 level in Oct. – Nov. and Nov. – Feb. crop season. The rate of multiplication of *M. incognita* at 250 level during July – Aug. and Feb. – April crop season was 102.45 and 100.06 times as compared to 57.72 and 81.92 times in Oct. – Nov. and Nov. – Feb. crop season respectively. Similar trend was observed at 4000 inoculum level also. The ratio of males and females was also influenced by the level of inoculum in different crop seasons. At inoculum level of 250 J2/plant the ratio of male: female was 1: 6.7, 1:6, 1: 6.2 and 1: 6.6 in July – Aug., Oct. – Nov., Nov. – Feb. and Feb. – April crops, while at inoculum level of 4000 it was 1: 5.4, 1: 5.1, 1: 5.3 and 1: 5.4, respectively.

Community Analysis of Plant-Parasitic Nematodes in Yamuna Khadar Region of Delhi

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An exploratory survey of the vegetable belt of Yamuna Khadar region of Delhi was conducted to assess the nematode community structure . Soil and root samples representing twenty locations were examined. Five important genera of plant-parasitic nematodes, namely, *Meloidogyne incognita, Tylenchorhynchus vulgaris, Hoplolaimus indicus ,Helicotylenchus indicus and Heterodera cajani* were widespread .*M.incognita* was present in 12 fields surveyed where brinjal (*Solanum melongena* L), tomato (*Lycopersicon esculentum* L.), chilli (*Capsicum frutescens* L.) and poi (*Basella rubra* L.) were being cultivated. The relative density of *M. incognita* was 63.6 and prominence value 628.9. Heavy root-knot galling on brinjal roots was observed at three locations where the population density of second-stage juveniles (J2) was 1698, 5573 & 3525 per 200 cm^3 soil. In a tomato field, the number of juveniles of *M. incognita* were as high as 5440 /200 cm^3 soil. The relative densities of *T. vulgaris, Helicotylenchus indicus* and *Hoplolaimus indicus* were 13.5, 13.4. and 5.4 and prominence values were 139.5, 101.2 and 59.7,respectively. *Heterodera* juveniles were found at only two locations giving a

relative density of 3.9 and a prominence value of 25.5. Most of the vegetable fields grown in this area showed symptoms of yellowing of foliage, stunting and patchy growth. Incidence of nematode caused damage of such high magnitude was first time observed on vegetables grown in and around Delhi.

Role of Defence Related Enzymes in the Resistance of Black Pepper to *Meloidogyne incognita*

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The post infectional changes in enzymes like superoxide dismutase (SOD), catalase (Cat), peroxidase (PO) and polyphenol oxidase (PPO) in *Meloidogyne incognita* – black pepper (*Piper nigrum* L.) pathosystem were studied in susceptible (Panniyur 1) and resistant (Pournami) varieties. The activity of SOD was lower in the inoculated plants of the resistant variety than in the uninoculated plants. The incrase in SOD activity in the susceptible variety, Panniyur 1, was maximum at 72 h after inoculation. The trend in catalase activity was also similar to that of SOD in both varieties. The peroxidase activity did not show much variation among the two varieties. On the contrary, the activity of polyphenol oxidase declined in the susceptible variety on inoculation with *M. incognita*, while its activity increased in the resistant variety, Pournami. Phenols also played a significant role in imparting resistance as indicated by the activity of PPO. The quantitative changes in the scavenging, antioxidant enzymes during the pathogenesis indicate a probable hypersensitive mechanism existing in the root-knot nematode resistant variety, Pournami.

Occurrence of Plant Parasitic Nematodes Associated with Wilt Disease Complex of Chickpea in Kanpur District

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Chickpea is one of the major pulse crops in Kanpur district. *Fusarium* spp. have been considered to be a major constraint for low yields. *Meloidogyne* spp. are known to interact with *Fusarium* spp. resulting in increased severity of wilt disease and breaking of resistance in wilt resistant cultivars. A survey on incidence of plant parasitic nematodes was carried out at 15-20 locations in different blocks of Kanpur district during rabi, 1995-96 and again in 1996-97 respectively in wilt affected chickpea fields. Root and soil samples were collected from wilt diseased plants, processed and analysed. Roots of chickpea plants affected with wilt were found with multiple galls. Mixed populations of *M. javanica* and *M. incognita* were found in 48 and 68% samples surveyed, respectively. *Hoplolaimus indicus*, *Tylenchorhynchus* spp., *Pratylenchus thornei* and *Rotylenchulus reniformis* were found in varying densities. A large number of saprozoic nematodes were also isolated from completely wilted chickpea plants. A regular association of plant parasitic nematodes in varying densities during two consecutive years indicated that

these nematode genera were involved in wilt disease complex of chickpea irrespective of cultivars and severity of disease. These results could form the basis for the future studies on the epidemiology of soil borne disease complex.

Effect of Root-Knot Nematode, *Meloidogyne javanica* (Pathotype-2) on Meteorological Parameters in Groundnut cv. GG 20

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An experiment was conducted to study the effect of root-knot nematode *M. javanica* pt-2 on meteorological parameters in groundnut cv. GG 20 in net house at 28-35o C temperature. An inoculum levels of 10, 100, 1000 and 10,000 of *M. javanica* pt-2 J2/plant were tried along with control (uninoculated). Effect of root-knot nematode, Mj pt-2 infection on meteorological parameters viz., leaf temperature, diffusion resistance and transpiration rate of groundnut leaves was studied. *M. javanica* pt-2 infection significantly increased leaf temperature and diffusion resistance over control, while transpiration rate proportionately decreased with an increase in inoculum levels, being maximum at the level of 10,000 J2/plant. Diffusion resistance and transpiration rate were inversely correlated. Inoculum level of 100 J2 and above/plant had drastically affected meteorological parameters. With an increase in duration of nematode infection, there was progressively more depressing effect on meteorological parameters.

Pathogenicity of Spiral Nematode, *Helicotylenchus dihystera*, on *Mulahtti, Glycyrrhiza glabra*

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Experiment was conducted with *Helicotylenchus dihystera* for observing the effects of nematode population on growth of *mulahtti* (*Glycyrrhiza glabra*) in pots and its consequent effect on reproduction of nematode. Inoculations were carried out with different population levels viz. 0, 10, 100, 1000, 10000 female and larvae per pot of *H. dihystera* to ascertain the pathogenic level. The observation on the effect of nematode inoculation on plant growth and the rate of multiplication of nematode after six months revealed a negative correlation between increased inoculum level of *H. dihystera* population and plant growth characters. Significant reduction in growth characters was observed at 100 and above nematode inoculation per pot. Highest nematode reproduction factor (402.66) was recorded at lowest inoculum level (10 nematode/pot) and lowest (2.42) at 10,000 inoculum level. *H. dihystera* was found to be pathogenic to *mulahtti* causing stunting, defoliation and reduction in fresh and dry weight of both shoot

and root system Histopathological observations revealed the browning of cortical cells in the roots at the entry points and at feeding site. The root systems of the uninoculated checks were healthy and has intact cortical tissue. The nematode penetration reached upto 2-3 layers of cortical cells. Reduction in chlorophyll, sugar and phenol contents in leaves was inversely proportional to inoculum level.

Host Response of *Terminalia tomentose* to *Cryphodera Kalesari* Bajaj *et al.*, 1989

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Histopathological changes in the roots of 'Sain', *Terminalia tomentose* induced by a non cyst forming heteroderid, *Cryphodera kalesari* Bajaj *et al* , 1989 were studied under light microscope after sectioning the infested roots in paraffin wax and staining with safranin and light green. Nematodes parasitized the roots all along its length. Infested roots exhibited no external symptoms of necrosis or galling. However, white-coloured females tended to erupt out of roots in several cases. Each female induced a single uninucleate giant cell (SUGC) measuring 75-117 x 40-80 um in the stelar region of the root. The cytoplasm of SUGC is dense and granular indicating high metabolic activity. The nucleus is hypertrophied, 19-24 um in diameter There was no necrosis or hyperplasia of cells adjoining SUGC. A few cells, nevertheless, in the vicinity of nematode head were lignified. Formation of SUGC in the host tissue by a *Cryphodera* sp., which is being reported for the first time, is similar to those reported for *Meloidodera, Hylonema, Sarisodera* and *Bellodera* genera of Heteroderidae.

Meloidogyne spp. Associated with *Cassava* in Kerala, Tamil Nadu and Pondicherry

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A survey was conducted to find out the distribution and frequency of *Meloidogyne* spp. associated with cassava in the major cassava growing regions of Kerala viz. Trivandrum, Alleppey, Thrissur and Calicut; Salem of Tamil Nadu and Union Territory of Pondicherry. Soil and root samples were drawn from four or five spots from a field and pooled together to obtain a composite sample. The identification of *Meloidogyne* species was based on measurements of second stage juveniles and perineal patterns. Two important species of *Meloidogyne* i.e., *M. incognita* and *M. javanica* were found associated with the crop. Trivandrum and Alleppey recorded only M. *incognita* where as Pondicherry and Calicut recorded *M. javanica.* Salem and Thrissur district however recorded both the species together. The root population was higher (1860-2712) in Salem and Thrissur where both the species were present whereas it was

low (272 to 832) in other locations where only one of the species were recorded. The highest frequency of *Meloidogyne* spp was found in Thrissur district (100%) followed by Alleppey (80%), Salem (62.5%), Pondicherry (60%), Calicut (53.33%) and the lowest in Trivandrum (46.15%).

Correlation and Analysis of Reduction in Plant Height in Wheat in Response to Infection by *Heterodera avenae*

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The parameter of plant height reduction is always considered as pathogenic response of nematodes and is correlated to the virulence and amount of inoculum added per pot/plant. In an experiment, to study the behaviour of two populations of *H. avenae*, wheat was sown on different dates of sowing i.e. 15 & 30 Nov. and 15 & 30 Dec. and also in another experiment, wheat was sown in different types of soils. The plant height was recorded every week during growth period of the plant till the termination of the experiment to analyse and correlated the time of maximum reduction in plant at various levels of inoculum. The observation and analysis of the data showed gradual reduction in plant height and is directly correlated to the level of inoculum added in the plant/pot. Maximum reduction in plant height was recorded at the time of appearance of white females in the plant usually at the time of laying of eggs within the swollen body i.e. reproductive phase of the nematode, irrespective of the date of sowing. The same behaviour was assessed when wheat was sown in different type of soils. It might be correlated with the nutrition vis-a-vis energy requirement by the nematode.

Studies on the Biotypes of *Heterodera avenae* Woll. in Haryana, India

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Four populations of *Heterodera avenae* collected from different districts were screened on 23 international host differentials comprising 13 of barley, 5 of oats and 5 of wheat. Based on the reactions, 3 biotypes of *H. avenae* were identfied. Population collected from Gurgaon and Mahendergarh districts appears biotype 1, expressing same susceptible/resistant reaction against all the differentials. Population from Ambala district forms another biotype 2, which produced cysts on Drost, Ortolan, Siri, Morocco, KVL 191 of barley whereas cysts were not formed on these host differentials by the populations from Gurgaon, Mahendergarh and Sirsa districts. Population from Sirsa district represent a third biotype which formed cysts on Sun II, Pusa hybrid, BS-1, *Avena sterilis*, Silva and Nidar cultivars of oats while populations from Mahendergarh, Gurgaon and Ambala districts did not form any cyst on these oat cultivars.

Effect of Root-Knot, Reniform and Lance Nematodes alone or in Combination on Growth Parameters of Cotton (*Gossypium hirsutum*)

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One week old seedlings of cotton (*Gossypium hirsutum*) cv. HS-6 were inoculated with *Meloidogyne incognita* race-4, *Rotylenchulus reniformis* and *Hoplolaimus columbus* either singly or in different combinations @ 1 nematode/g soil. Concomitant occurrence of nematodes resulted in significantly more damage to growth parameters viz. plant height, shoot and root weights than either nematode alone. Plant height (24 cm), fresh shoot (8 g) and root weights (4 g) were minimum in the treatment in which all the three nematodes were present in comparison to uninoculated controls (44.5, 19.5 and 11.5, respectively). All the three nematodes multiplied well on cotton when present alone. In concomitant occurrence fecundity and population build up of all the three nematodes was reduced due to competition.

Identificaiton and Distribution of *Xiphinema* spp. in Temperate Horticulture Zone of Himachal Pradesh

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The present study was based on faunistic surveys conducted during the last 14 years (1985-99) for assessing the incidence and its distribution of *Xiphinema* species in horticultural and flower crops in Himachal Pradesh. The results revealed that the plant parasitic nematodes including *Xiphinema* were found in abundance. A little information is available on the occurrence of *Xiphinma* species from high altitude cold zone in North-West region of Himalaya which comprises Lauhal Spiti, Chamba, Kullu, Kinnaur, Sirmour and Shimla districts of Himachal Pradesh. This zone is characterized by low rainfall during summer months (25-40 cm) and heavy snow fall during winter (1-5 m). This region constitute the highly variable soil type as clay, loam, sandy loam and sandy soils with different PH (5.8-7.2). The area covers with low land to high mountains and ranging from 4000 fts to 12000 fts (amsl) height from where the species of genus *Xiphinema* Cobb, 1913 were encountered and identified as *Xiphinema bergeri*, Luc, 1973 *X. americanum*, Cobb, 1913 *X. diversicaudatum* and *X. basiri* Siddiqi 1959. In general, higher population of *Xiphinema* are found in association with perennial crops than cultivated land. Nevertheless, the distribution of most of the commonly occurring *Xiphinema* species among all types of vegetation is indicative of polyphagy, but *X. diversicaudatum* has shown little host specificity, especially where the chance of virus incidence is more as this species has been found in association with virus out- breaks in grape, strawberry and peach.

Interaction of *Meloidogyne incognita* with *Fusarium oxysporum* on Cauliflower

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Maximum wilt score (4.0) and wilt symptom index (63.43) was observed in plants which received nematodes 14 days before the inoculation of wilt fungus, followed by treatments, nematodes 7 days before fungus, fungus 7 days before nematode, fungus-nematodes simultaneous inoculation and fungus 14 days before nematode. There was more wilting in cauliflower plants when nematode was inoculated prior to fungus. The effect of nematode-fungus simultaneous inoculation as well as fungus 7 days before nematode inoculation was more or less same on expression of wilt score and wilt symptom index. There was significant increase in number of root-knot as well as in final nematode population where, only nematodes were inoculated. More number of galls and final nematode population were recorded in treatments where nematode was inoculated prior to fungus than where fungus was inoculated prior to nematode. There was significant reduction in shoot and root length as well as in fresh and dry weight of shoot and root in all treatments when compared with uninoculated check.

Effect of Inoculum Level of *Meloidogyne incognita* on Nitrate Reductase Activity of Nodules and Leaves at Different Growth Stages of Gram (*Cicer arietinum* L.)

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The roots of gram (*Cicer arietinum* L) may be infected by both *Rhizobium* and *Meloidogyne incognita* for the formation of nodules and galls respectively under field conditions. *M. incognita* has been reported to interfere in the uptake and transportation of nutrients. As nitrogen is one of the most important plant nutrients so its uptake under the influence of infection by *M. incognita* was studied in nodulated gram (*Cicer arietinum* L) variety PB-1. For this, earthen pots were filled in with unsterilized sandy loam soil collected from field. Nitrogen was applied @ 10 ppm before sowing. Seven days old seedlings were inoculated with 10 ml. suspension containing 500, 1000 and 2000 freshly hatched second stage juveniles/pot. Nitrate reductase activity of nodules and leaves were measured at three growth stages viz. pre-flowering, flowering and post flowering. It has been found that different inoculum levels exerted varied effects on total chlorophyll contents of leaves as well as nitrate reductase activity of nodules and leaves. Total chlorophyll contents of leaves was minimum (0.55 mg/0.5 leaves) when 2000 juveniles were inoculated/pot at pre-flowering stage. Total chlorophyll contents declined after flowering at all inoculum levels of nematodes. Nitrate reductase activity of both nodules and leaves decreased at all the three levels of nematodes as compared to uninoculated control. At pre-flowering stage Nitrate reductase activity of nodules and leaves was

0.541 and 0.275 m NO_2/h/g respectively when 2000 juveniles were inoculated. Nitrate reductase activity decreased with increase in the age of the plants after flowering. It is, therefore, evident that with increase in the inoculum level of nematodes and age of the plants, there was decline in the uptake and transportation of nitrate as well as total chlorophyll contents of leaves.

Investigation on Severe Infestation by *Aphelenchoides besseyi* in Tuberose (*Polianthes Tuberosa*)

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Survey on floral malady of tuberose revealed that *Aphelenchoides besseyi* was a serious pest of tuberose in West Bengal. Pathogenicity of *A. besseyi* in rice and tuberose were tested. The nematodes failed to infect on chrysanthemum and *Echinochloa colona*. Two fungi viz. *Fusarium* sp. and *Alternaria* sp. were isolated from infested leaves and flowers of tuberose and *A. besseyi* was found to develop and multiply on *Fusarium* sp. in Potato-Dextrose-Agar (PDA) medium. Observation on population fluctuation of *A. besseyi* in tuberose cultivar "Double" indicated that the highest population (35,000 per flower stalk) of this nematode was during rainy season (July – September) and lowest (674 per flower stalk) during summer months (March-June).

Nematode Community Analysis of Cotton Rhizosphere Soils of Northern Karnataka

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A nematode random survey undertaken in the cotton growing areas of northern Karnataka for the associated nematodes showed the presence of mainly *Rotylenchulus reniformis, Hoplolaimus* sp., *Pratylenchus* sp. apart from some dorylaimid pathogens. Community analysis of the associated nematode genera demonstrated that the above tylenchid nematodes are important in the forementioned order in the cotton growing areas surveyed. Pathogenic nature of reniform nematode was demonstrated in greenhouse studies, a first such effort on cotton in Karnataka, in respect of this important nematode pathogen. A well known cultivar Sharada (CPD-8-11) was found susceptible.

Effect of Different Soil Salinity Levels on Root-Knot Nematode, *Meloidogyne incognita* infecting Cotton.

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A screen-house study was conducted to see the effect of different electric conductivity (soil salinity) levels on the reproduction and multiplication of *M. incognita* in cotton (*Gossypium hirsutum* cv H-777). Various soil salinity levels viz. 0.4, 0.8, 1.2 and 1.6 dSm-1 were prepared by mixing Na_2SO_4, $CaCl_2$ and $MgCl_2$ in sandy soil and earthen pots (15 cm size) each were filled with one kg. such soil for each salinity level under nematode inoculated (1 J2/g soil) as well as non inoculated conditions. The observations recorded 3 months after nematode inoculation revealed that all growth parameters of cotton plants except dry root weight were minimum and significantly less in treatments receiving nematode inoculation as compared to non-inoculated conditions irrespective of soil salinity levels. Growth of cotton plants as well as nematode galling, egg masses, eggs/egg mass and final nematode population in the soil decreased with increased soil salinity (E C.) levels from 0.8 to 1.6 dSm-1 as compared to non-saline check. However, the interaction between various salinity levels and nematode inoculation vs non-inoculation was non-significant for plant growth parameters.

Incidence of Infection of Reniform Nematode, *Rotylenchulus reniformis* in and around Udaipur Region of Rajasthan

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The reniform nematode, *Rotylenchulus reniformis* has been recognised as one of the important pest next to only root-knot nematode in India. This nematode pest is a polyphagous, cosmopolitan and considered to be highly pathogenic to a variety of crops. The agroclimatic conditions of Udaipur are most feasible for the survival and fast multiplication of this nematode. Keeping this in view, an investigations on reniform nematode associated with various available crops and weeds, were carried out to find out its distribution, percentage of occurrence, areas of high severity and host association in Udaipur region of Rajasthan. A total of 674 soil and root samples of various crops were collected from 37 different localities of Udaipur. Out of 647 soil and roots samples 496 samples showed the presence of *R. reniformis* which constitute 73.59% occurrence. Hundred percent occurrence was however recorded in six localities whereas 90-99% occurrence was found in three locallities, while 26 localities showed 51-90% occurrence, remaining two localities showed below 50% occurrence. The highest average percentage of population density was found on castor (67.10%) followed by brinjal, tomato, chilli, cauliflower and gram whereas it was lowest in barley, onion and wheat. The prominence value ranged from 33.87 (mustard) to 671.07 (castor). Some crops viz. onion, bittergourd,

bottlegourd showed complete absence of reniform nematode in various localities. Out of 11 common weeds, which were found associated with reniform nematode, *Parthenium hysterophorus, Oxalis* sp. and *Meliotus indica* were recorded as new hosts for reniform nematode.

Effect of different pH levels on the reproduction of plant parasitic nematodes and the growth and oil yield of *Mentha spicata*

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Studies were done to determine the effect of different pH levels (4.0, 5.0, 6.0, 7.0, 8.0, 9.0) on the reproduction of plant parasitic nematodes (*Rotylenchulus reniformis* – 20% + *Helicotylenchus indicus* – 20% + *Tylenchorhynchus vulgaris* – 20% + *Hoplolaimus indicus* – 20% + *Pratylenchus thornei* – 15% + *Xiphinema* sp. – 5% = 5000 nematodes/pot) and the growth and oil yield of spearmint, *Mentha spicata* cv. MSS-5. An inversely proportional relationship was observed between pH levels and plant growth parameters of uninoculated plants. Highest suppression of plant growth parameters and oil yield was observed at pH 7.0 followed by 8.0, 9.0. 6.0, 5.0 and 4.0 respectively. Maximum reduction in root length (25.8%), shoot height (27.2%), root and shoot fresh (35.6 and 37.5%) and dry (32.9 and 37.1%) and in oil content (38.6%) of fresh herb was observed at pH 7.0 and minimum (2.5, 1.5, 1.1, 2.9 and 0.0% respectively) at pH 4.0. Significant reduction in various test parameters was observed in inoculated plants irrespective of pH levels. Influence of all the pH levels on reproduction of total plant parasitic nematodes was observed to be significant. Highest reproduction of plant parasitic nematodes was observed at pH 7.0 (Rf = 21.9) followed by 8.0 (20.5), 9 0 (18.3), 6.0 (14.3), 5.0 (9.5) and 4.0 (5.2) respectively. Results indicate that spearmint grows better at lower pH with least damage due to plant parasitic nematodes.

Surveillance of Ear-Cockle Nematode, *Anguina tritici* of Wheat in Punjab and its Management

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Anguina tritici is known to attack wheat in Punjab and reduce its yield. Surveillance of ear cockle disease in the Punjab was carried out from 1989-99. Grain markets were surveyed during May every year and 15-20 wheat lots brought by farmers for sale were examined for the occurrence of ear cockle galls in them. The number of galls/3000 grains were recorded from each infested lots to find out the intensity. The per cent prevalence of disease was found to be 12.17 in 1989, 7.18 in 1990, 4.32 in 1991, 5.96 in 1992, 2.42 in 1993, 4.57 in 1994, 2.14 in 1995 and 1.28 in 1996. Prevalence was

found to be reduced to 0.62, 0.89 and 0.34% in 1997, 1998 and 1999 respectively. A corresponding decrease in the intensity of occurrence of disease was also recorded. Field studies have revealed that the same level of inoculum (6%) of ear-cockle nematode produced 5.17 and 10.16% disease, when sowing of wheat was done in the first and second fortnight of November, 12.94 and 14.27% disease when sown in first and second fortnight of December respectively. Studies were also conducted in the field to find out the effect of seed treatment with different pesticides on ear cockle disease. Seed treatment with chlorpyriphos @ 4 ml/kg for 4 years was found to reduce the disease on an average by 89.7% over control Three brands of chlorpyriphos viz., Dursban, Ruban and Durmet 20 EC were found to be equally effective @ 4 ml/kg seed and resulted in 96.5, 98.8 and 98.4% reduction in disease over untreated control.

An incidence of disease complex caused by root-knot Nematode , *Meloidogyne incognita* and wilt fungus *Fusarium solani* infecting Poi (*Basella rubra*)

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During the month of August a survey was conducted in Yamuna river belt of Delhi. A crop of leafy vegetables Poi (*Basella rubra*) belonging to the Family – Basellaceae was found to be infected with wilt disease. On uprooting the plants it was also observed to be heavily infected with root-knot nematode. The wilt pathogen was identified as *Fusarium solani* while the root-knot nematode as *Meloidogyne incognita*. The crop was affected to the extent of 45%. A preliminary trial conducted under pot conditions showed both nematode and fungus pathogenic to host and there concomitant attack expressed synergistic effect. This is the first report of disease complex due to interaction of *M. incognita* with *F. solani* on Poi.

Nematode Control by Genetically Modified Crops

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Genetically modified plants recreated by the process of genetic engineering, which allows scientists to move genetic material between organisms, of different genera or species with the aim of changing their characteristics. Engineering a plant with the ability to produce an antibody, or antibody fragments, to specifically bind and inactivate a biologically active molecule has promise to open new avenues for novel plant resistance against nematodes. A transgenic anti-feedant approach aimed at achieving control against a range of nematode species is being developed. The basic design of resistance strategy centres on inhibitors o nematode digestive proteinases. The approach has been developed by engineering proteinase inhibitors to improve their inhibitory activity. Expression can be controlled by a root specific promoter to provide a standing defense against a range of nematodes. Genes that provide resistance against nematodes are obvious candidates for transfer. *Mi* has provided resistance in tomato to the *Meloidogyne*

incognita for many *years* and is currently the focus of cloning efforts by several groups. Efforts are being made to transfer Mi to potato and cucurbits, which may provide effective resistance to this important pest Several lines of evidence suggest that interspecific transfer may provide resistance to pathogens of the recipient species. Although highly effective in many conditions, *Mi* fails to provide resistance at high soil temperatures and *Mi* virulent nematode isolates have been identified in many areas of the country. These findings have stimulated us to make efforts to identify new sources of root-knot nematode reistance. The Mi gene alongwith other genes would broaden the base of resistance in many host crops.

Population Dynamics, Resistance and Cultural Practices

Effect of different Times of Sowing on Plant Growth and *Rotylenchulus reniformis* Infecting Pea (*Pisum sativum* L.)

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A pot trial was carried out in screen-house to assess the effect of time of sowing of pea cv. Arkel on plant growth parameters and *Rotylenchulus reniformis* population build up. Pea was sown on three different dates viz., on 30th September, 15th October and 30th October. Observations on plant growth and yield of pea along with the nematode population were recorded ninety days after sowing. Significant increase in plant growth and yield of pea was recorded in late sown crop i.e. 30th October in comparison to mid October and 30th September (early sown) pea. Significant reduction in nematode fecundity and population build up was noticed in late sown pea over the early sown pea.

Effect of Intercropping of Paddy with Legume Crops on *Hirschmanniella* spp.

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Paddy variety Saket 4 seeds were soaked for 24 hrs. After 24 hrs. the seeds were covered with wet gunny bag in the dark room for 48 hrs.for faster germination. After 48 hrs. the germinated seeds were sown in 3x3 meter basal fertilized microplots. Intercropping of paddy Saket 4 were alternating with the rows of cowpea and groundnut. Each treatment were replicated four times. The fertilizers, Nitrogen, Phosphorus and Potash (N, P, K) were applied @ 100, 40 and 60 kg/ha as a basal fertilizer. One top dressing was done when the plant initiated flag leaf. Results indicated that the intercropping of legume crops with paddy reduced *Hirschmanniella* spp. The highest plant growth, total no. of grain/panicles and test wt. of grain were found for Paddy (Saket 4) with intercropping legume crops. The other plant parasitic nematodes present in the plot were *Meloidogyne* spp., *Helicotylchus* spp., *Hoplolaimus* spp. and *Tylenchorhynchus spp.*

Effect of Crop Rotation on *Heterodera cajani*

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Various crops namely red gram, black gram, sudan, green gram, pearl millet, cowpea, sunhemp, tomato, wheat and brinjal were used as a crop rotation to the heavily infested field of *Heterodera cajani*. The experiment was started from July 1996 to November, 1997. Every month the observation were made on the cyst population in 500 g of soil and also according to the season the crop was changed. Result indicate that one and half year crop rotation done to the infested field can reduce *H. cajani* population upto the minimum threshold level and also it improved the fertility of the soil. Continuous growing of susceptible host crop in the *H. cajani* infected field can increase the population of *H. cajani* 10-15 times in a year from the initial population.

Dynamics of Plant Parasitic Nematodes associated with Cotton in Nagpur Region

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A 2 year intensive survey in cotton growing areas of Nagpur indicated association of plant parasitic nematodes belonging to 8 genera with cotton and cotton based cropping systems. Reniform nematode, *Rotylenchulus reniformis* was the predominant species, Frequency of occurrence having 100% in majority of samples (89%). Other important plant parasitic nematodes recorded were: *Helicotylenchus* sp., *Tylenchorhynchus* sp. *Pratylenchus* sp. and *Hoplolaimus* sp. Pre-sowing populations of *R. reniformis* were recorded to be well below threshold level but after 45 days of sowing threshold limit was crossed. *R. reniformis* showed two peaks, a low during summer and high in autumn/winter. Populations of plant parasitic nematodes were higher in 15-30 cms soil layer than at upper 0-15cm or lower 30-45 cms layers. In rotations involving soybean and cowpea, four fold increase in *R. reniformis* population was recorded. Rotation involving jowar resulted in reduction in population of *R. reniformis*. Four weed species, *Amaranthus* sp., *Trianthema monogyna*, *Convolvulus arvensis* and *Echinochloe* sp. occurring in cotton were studied for their status as host to *R. reniformis*, *Amaranthus* sp., *Trianthema monogyna* and *Convolvulus arvensis* were recorded as good hosts while *Echinochloe* was a poor host.

Efficacy of Cultural Practices in Managing Rice-Root Nematode, *Hirschmanniella oryzae* Infecting Paddy

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Management of rice-root nematode, *Hirschmanniella oryzae* through cultural practices was studied for two consecutive years (1997-98 and 1998-99). Infested soil having nematode population level of 72 nematodes/100 cc was taken for study. Two species of *Dhaincha, Sesbania aculeata* and *S. rostrata* were either grown for 45 days and mixed in the infested soil or removed from the pots after 45 days. The efficacy of cultural practices was compared with chemical treatment (carbofuran @ 1.0 kg a.i./ha). In all there were five treatments alongwith check, in which only recommended inorganic fertilizers were applied. Paddy variety PR-106 was transplanted 35 days after germination. Data on grain yield per pot, nematode population in soil (per 100 cc) and in roots (per 1.0 g) were recorded. During 1997-98 maximum grain yield (49.02 g) was recorded in carbofuran treated pots. Among the cultural practices, *S. aculeata* grown for 45 days and mixed in soil was found the best which registered 42.35 g grain yield; and minimum yield (29.35 g) was recorded in control pots. Soil nematode population at harvest was recorded minimum (7.65/100 cc soil) in carbofuran treated pots. However, *Sesbania aculeata* grown and mixed in soil (T2) was found most efficient in reducing nematode population in soil. Root population (per 1.0 g) also showed the similar trend where it was recorded maximum (339.9)in control pots and minimum (97 5) in carbofuran treated pots. During 1998-99 grain yield was recorded maximum (34.12 g) in carbofuran treated pots. However, amongst cultural practices it was *S. aculeata* as T2 which significantly increased grain yield as compared to other treatments. Soil and root population were recorded minimum in control pots. Among the cultural practices, *Dhaincha, S. aculeata* grown and mixed in soil proved most efficient in reducing the nematode population as compared to other treatments including control.

Population Dynamics of *Heterodera cajani* associated with Pigeonpea in Various Cropping Systems

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Pigeonpea (*Cajanus cajan* (L)) is an important pulse crop. Cultivation on marginal land with less means and other biotic factors are mainly responsible for its low production. Farmers regard crop rotation as a pragmatic way to sustain soil fertility and better production. The rationale of this study was to find out influence of the cropping system on density & occurrence of pigeonpea cyst nematode (*Heterodera cajani*) and to identify useful cropping system for reducing the nematode population, which is the most damaging nematode and constitute about 70% of the total nematode population present in this system. The common practice of cultivation prevalent in this region are

intercropping of pigeonpea with sorghum, maize, guar and green gram. In cropping sequence, it is grown after summer fallow (May-June) or green gram or sunflower preceded by wheat or mustard crop. These fields were sampled for parastiic nematodes from 100 cm^3 soil samples collected in the month of July, September, and finally at the time of harvesting *Heterodera cajani* population was highest (760 J2 and eggs/100 cm3) in sole pigeonpea crop, pigeonpea/sorghum and pigeonpea/green gram intercropped fields in comparison to intercropping with guar or maize. In sequence cropping it is comparatively reduced by 15 to 20% when subjected to crop rotation with sunflower or summer fallow preceded by mustard crop. But one year crop rotation did not influence the population density of *H. cajani*. Two year crop rotation, sowing of tolerant pigeonpea variety and intercropping with non-host crop can reduce the incidence of cyst nematode.

Nematode Community Analysis of Cotton Rhizosphere Soils in Northern Karnataka*

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A random survey undertaken in the cotton growing areas of northern Karnataka for the associated nematodes showed the presence of mainly *Rotylenchulus reniformis, Hoplolaimus* sp, *Pratylenchus* sp. apart from some dorylaimid nemaatodes. Community analysis of the associated nematode genera demonstrated that the above tylenchid nematodes are important in the forementioned order in the cotton growing areas surveyed. Pathogenic nature of reniform nematode was demonstrated in greenhouse studies, a first such effort on cotton in Karnataka, in respect of this important nematode pathogen. A well known cultivar Sharada (CPD-8-11) was found susceptible.

Annual *Chrysanthemum*, a Possible Trap Crop for the Cereal Root-Knot Nematode, *Meloidogyne triticoryzae*

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The root-knot nematode, *Meloidogyne triticoryzae* thrives well in the rice-wheat cropping system. The nematode population grows several fold in the rice crop in *Kahrif* season and also has some reproduction in the following wheat crop in *Rabi* season. The low temperature in the is a greater limiting factor than the wheat crop which is an equally good host under warmer condition. Crop rotation with a non-host would be a good approach to manage this nematode. However, many of the eggs do not hatch for a long time and appear to respond to the root diffusates of a host crop. A crop, that is able to induce hatch and allow invasion but not normal development, would serve as a good trap crop and reduce the population density more than a normal non-host crop.

The patterns of infection and development of *M. triticoryzae* were studied on annual *Chrysanthemum* with multifloret white or yellow flowers. When inoculated

artificially or grown in infested soil, the infective second stage juveniles penetrated normally and the roots were galled severely. However, the development of the nematode was slow and less than 2% of the invading juveniles could attain maturity and reproduce compared to more than 25% in the wheat cv. HD-2329 under similar conditions of temperature and moisture. The maturing females produced very few eggs Studies on the development of the galls revealed that the giant cells were not maintained properly and the stele became knotty and hard. The population density in the soil was reduced to 40% in soil without host and to 15% of the initial under annual *Chrysanthemum*, while it increased more than three times under wheat during a period of 100 days. Thus, annual *Chrysanthemum* had the attributes of a trap crop and since the crop gives profuse yield of beautiful flowers with good commercial value, it may serve as a useful trap-cum rotation crop to sometimes replace wheat in *Rabi* season for effective nematode management. However, more feasibility studies in field are required before a recommendation can be made.

Population Behaviour of Concomitant Populations of *Hirschmanniella oryzae* and *Meloidogyne triticoryzae* in Rice – Wheat Cropping System Over a Period of Ten Years

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The population density of nematodes determined by a number of edaphic conditions and the plants growing, including weeds and crops over a period preceding the point of observation. Species of nematodes differ in their preferences and adaptations for such conditions and plants. Therefore, shifts in the community structure of nematodes are expected over a period of time even at the same location. The population behaviour of plant parasitic nematodes was studied in a field under rice-wheat cropping system over a period of ten years. The field was subjected to conventional tillage before wheat and puddling before transplanting rice. Initially, the field had a moderate population density of the root-knot nematode, *Meloidogyne triticoryzae,* a sedentary vascular feeding root endoparasite and very few, almost undetectable levels of the rice root nematode, *Hirschmanniella oryzae*, a migratory cortical feeding endoparasite. During the first three years the *M. triticoryzae* population density increased further while *H. oryzae* was recorded only occasionally. After four years, however, the *M. triticoryzae* population density did not increase further but *H. oryzae* population density started increasing slowly. By the end of eight years of observation the density of *M. triticoryzae* declined gradually and that of *H. oryzae* increased; the trend continued during the last two years resulting in a very low population density of the root-knot nematode but an abundance of the rice-root nematode. This shift in the community structure could be attributed to differential ecological preferences of the two nematodes; the *H. oryzae* survived better under thoroughly puddled and flooded soil conditions in rice than the root-knot nematode. The introduction of root-knot nematode-free rice seedlings and more puddling in this field as a part of a nematode management package might also have been responsible for the shift in the community structure of nematodes.

Nematode Population as affected by Paddy based Cropping Sequences

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Paddy based cropping sequences for three consecutive years in nematode infested field of sugarcane showed significant effect on the population of stunt (*Tylenchorhynchus mashhoodi)* nemataode. Paddy-gram reduced nearly 100 per cent population followed by paddy - ;methi (73.1%), paddy – lentil (58.3%) while mono culture of sugarcane increased the population continuously.

Influence of Oilseed Cakes on Root-Knot Nematode, *Meloidogyne javanica* infecting Smooth Gourd

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An attempt was made to study the effect of oilseed cakes such as mustard cake (MC) and 'til' cake (TC) each @ 10g, castor cake (CC) and deoil castor cake (DCC) each @ 5, 10, 15 and 20g/kg soil on root-knot nematode, *Meloidogyne javanica* infecting smooth gourd cv. local under screenhouse conditions. Finely ground cakes were incorporated in nematode infested soil and allowed to decompose for 10 days. 45 days after sowing, observations were recorded on plant growth parameters and root-knot index. All the cakes were found effective in increasing height and weight of plant over control and carbofuran. Root-knot index was recorded minimum in MC, TC each at 10g, CC at 10,15, 20 and DCC at 20g/kg soil as compared to other doses tested.

Effect of Nimin® and U-Coat® as Urea Coatings on Root-*Knot and Reniform Nematodes in Okra*

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Root knot (*Meloidogyne incognita*) and reniform (*Rotylenchulus reniformis*) nematodes are major nematode pests of okra (*Abelmoschus esculentus*) in India. Nimin® and U-Coat®, two neem based urea coatings, increased crop yields by slow release of nitrogen in the soil. The present investigations were conducted to find the effect of Nimin® and U-Coat® as urea coatings on the root knot and reniform nematodes in okra in two glasshouse experiments conducted in two successive rainy seasons. The first experiment was conducted in 10-cm dia. plastic pots having infested soil with 1-second stage juvenile/g of *M. incognita* and 3 infective female/g of *R. reniformis*. Two seeds of okra (cv. A4) were sown in each pot and after germination only one plant per pot was kept. Urea was treated with Nimin® and U-coat® @ 500g/50kg and applied @ 120 kg

N/ha (recommended dose) to 15-day old plants. Two checks were kept one without urea application and another with untreated urea. All treatments and checks were replicated four times. Observations were taken after 75 days revealed that the reniform nematode dominated at the harvest with undetectable levels of root knot nematodes in roots as well as soil in all treatments and checks. So, the details were recorded for *Rotylenchulus reniformis* only. Nimin® and U-coat® significantly reduced (P=0.05) different stages of reniform nematode including females and egg-masses than both the checks though reduction was only about 20%. However, there was significant improvement in shoot and root length and weight with both the treatments as compared to checks. Another experiment was conducted in the in 30 cm dia. earthen pots containing soil naturally infested with root knot (2 second stage juveniles/g) and reniform nematodes (2 pre-matured females/g). Urea treated with Nimin® and U-coat® was applied as described above. In this case, only one check of untreated urea was kept. The crop was harvested after 100 days and the nematode populations in soil and number of root knot nematode galls were recorded. Observations on shoot and root height and weight and fruit harvest were also taken. Both Nimin® and U-coat® significantly reduced (P=0.05) number of galls by 36- 38%, root knot and reniform nematode populations in soil by 20-23% and improved plant growth and fruit harvest. The two formulations, meant for urea coatings (for improved fertilizer efficiency), could also restrict root knot and reniform nematodes.

Screening of Tomato Germplasm against Root-Knot Nematode (*Meloidogyne Incognita*)

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Tomato (*Lycopersicon esculentum* (L)) is an important vegetable crop growing throughout the country. Twenty four germplasm of thirty days old tomato seedlings were transplanted in sterilized potted soil prepared in 2:1:1 ratio of soil, sand and compost. The soil mixture of pot soil was incorporated with two freshly hatched larvae of root-knot nematode (*Meloidogyne incognita*) a day before transplanting. The experiment was replicated three times. Ninety days after transplanting the plants were depotted and washed to free soil from tomato plant roots. The number of root-galls were graded according to 5 point root-gall index. Of the tomato cultures six, namely, 8308, 8307, 8301, 1098, 8745 and 8202 were highly resistant and showed no response of gall formation. Cultures 8609, 8713 were recorded resistant and 8725, KS 176 as moderately resistant, graded in 1.00and 2.00 root-gall index, respectively. Rest of the germplasm/culture of tomato were graded in susceptible and highly susceptible categories having 3 to 5 root-gall index.

Effect of Aqueous Extracts of Plant Products on Hatching and Penetration of *Meloidogyne incognita* in Sunflower

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The aqueous extracts of leaves of neem (*Azadirachta indica*), ak (*Calotropis procera*) Dek (*Melia azadrach*) and oilcakes of mustard and cotton were tested on the hatching and penetration of root-knot nematode, *Meloidogyne incognita* on sunflower plants. The maximum inhibition of hatching occurred at N and N:10 concentration of aqueous extracts o all the plant products. Cotton cake was found to be the best in causing maximum inhibition. However, the lower concentration (N:80) was comparativey less effective. Penetration by the second stage juvenils of the nematode into the roots of sunflower plant was significantly inhibited by all the plant products over control. However, higher doses i.e. 20 and 40/kg soil were better in suppressing the penetration by the juveniles. Further cotton cake caused maximum suppression in the penetration.

Interactions of Nematodes with other Organisms

Suppressive Role of Bacteria associated with *Tagetes* Roots on *Meloidogyne incognita*

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Tagetes erecta and *T. patula* are known for their antagonistic properties against several plant parasitic nematodes. In the present study filtrates from bacteria associated with *T. patula* roots were tested *in vitro* on *Meloidogyne incognita*. Roots of field grown *T. patula* were washed in sterilized distilled water (SDW) and cut into small pieces. Few of these pieces were boiled in SDW for 10 min. Bacteria were isolated from these boiled and unboiled root pieces separately on nutrient agar. Two bacteria from unboiled root pieces designated as A and B and one from boiled root pieces designated as HRB (heat resistant bacteria) were subcultured on nutrient broth for 24 h. Cell free filtrates were obtained by filtering the broth with Whatman filter paper no1 and thence millipore filter. These filtrates designated as 'S' (standard) and their 5, 10 and 100 times dilutions (designated as S/5, S/10 and S/100, respectively) were tested on second stage juveniles of *M. incognita*. Observation at 24, 48 and 96 h revealed - i) 100% juvenile mortality at 24 h observation in 'S' of all the three bacterial filtrates and in 'S/5' of 'A' and 'HRB'; ii) 100% juvenile mortality at 48 h in 'S/5' of 'B' and iii) 43, 47 and 42% mortality at 96 h in 'S/10' of 'A', 'B', and 'HRB', while none died in water (check). This study is indicative of suppressive role of *Tagetes* root-associated bacteria on *M. incognita*.

Management of Root-knot Nematode through the Plant Rhizosphere Bacterium *Pseudomonas fluorescens* Migula

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Area under vegetable cultivation in the country has come down considerably in recent years owing to the attack by pests and diseases, especially root-knot nematode, *Meloidogyne incognita.* Management of phyto-nematodes by chemicals has been studied for over three decades. Due to health and environmental hazards, currently greater emphasis is given to explore feasible and eco-friendly management strategies against phyto-nematodes. Thus *Pseudomonas fluorescens* Migula, a potential biocontrol agent for nematodes, available as commercial formulation in Tamil Nadu Agricultural University, Coimbatore, was evaluated in this study for the management of root-knot nematode in brinjal nursery. The results were evaluated with solarization of nursery beds with 150 gauge polythene sheets (low density polyethylene film) for 15 days during peak summer period , nursery application of AMF, *Glomus fasciculatum* 5g spore medium @

200 spores per g medium and neem cake @ 200 g per m^2. The performance of the seedlings in the main field was also evaluated. The results revealed that solarisation of nursery beds with polythene sheets (LDPE film), nursery application of AMF, *Glomus fasciculatum,* bacterium *Pseudomonas fluorescens* and neem cake improved the growth of brinjal seedlings by reducing the native population of phytonematodes. The field studies conducted revealed that this initial protection of seedlings improved the yield of brinjal from 15 to 20 per cent. The economics, merits and demerits of these treatments were also studied.

Host Specificity of *Pasteuria isolates* from *Heterodera cajani, H. zeae* and *Xiphinema insigne*

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Four populations of *Heterodera cajani*, one each of *H. zeae* (race-2) and *Xiphinema insigne* originating from different parts of India were found infected with *Pasteuria* sp. in the culture pots maintained separately in the screen house of Department of Nematology, CCS HAU, Hisar. The bacterial isolates were designated as HCP I, HCP II, HCP-III, HCP IV; HZP, XIP, depending upon source and origin of bacterium and nematode host. Infected females of *H. cajani*, *H. zeae* and *X. insigne* were crushed separately in water. The number of spores of each isolate was adjusted to 2 × 10^5 per ml. In a replicated trial, ca 100 nematodes of the test species held in 2 ml of water were exposed to an equal volume of each spore suspension in 5-cm petri plates at room temperature. After 72-hours exposure 20 nematodes from each replicate were observed microscopically for encumberance of spores. Spores of four HCP isolates originating from Anand (HCP I), Coimbatore (HCP II), Kanpur (HCP III) and Hisar (HCP IV) populations of *H. cajani* encumbered the J_2 of Anand, Coimbatore, Dharwar, Hisar (both race A and race-B), Jaipur, Kanpur, and Yamunanagar populations of *H. cajani*. However, the rate of encumberance varied among bacterial isolates and *H. cajani* populations. The spores of all four isolates failed to attach to *Anguina tritici*, *Aphelenchoides composticola*, *Helicotylenchus* sp., *H. mothi*, *H. zeae* (race-1, 2 and 3), *Hoplolaimus indicus*, *Longidorus siddiqii*, *Meloidogyne incognita*, *M. javanica*, *Pratylenchus zeae*, *Rotylenchulus reniformis*, *Tylenchulus semipenetrans*, *Xiphinema insigne* and *X. basiri*. HZP spores attached to J_2 of *H. avenae* (Haryana, Himachal and Rajasthan populations), *H. cajani* (race A), *H. zeae* (race 1, 2 and 3) and *Verutus mesoangustus* but failed to encumber *H. graminis*, *H. mothi*, *H. sorghi* and *M. incognita* second stage juveniles. XIP spores attached only to *X. insigne* but did not encumber the juveniles of *H. cajani*, *H. zeae*, *H. mothi*, *M. javanica* and juveniles and females of *X. basiri*.

Screening of some Pea Varieties/Germplasm for Resistance to *Meloidogyne incognita*

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A pot experiment was conducted to screen 22 pea varieties/germplasm obtained from Pulse Directorate, Kanpur (UP), against root-knot nematode, *Meloidogyne incognita* to find out sources of resistance. After one week of sowing the plants were inoculated with $2J_2$ of *M. incognita*/cm^3 soil. After germination only one well established plant was maintained. Observations after 40 days of inoculation were recorded on number of galls and eggmasses per plant, eggs and juvenile per egg mass, root-knot index. On the basis of these parameters, out of 22 varieties/germplasms, two varieties, viz., IET (DDR-17) and HUP-15, were found resistant, while AVT-1 (DDR-14) and HUP- were found to be moderately resistant and Bonneville and HUDP-7 were highly susceptible.

Studies on the Predation Abilities of *Mesodorylaimus bastiani*

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Observations were made on the predation abilities of *Mesodorylaimus bastiani* using *Hirschmanniella oryzae* and second stage juveniles of *Meloidogyne incognita* as prey in small pots containing soil. The predatory pattern of *Mesodorylaimus bastiani* was observed over a period of ten days using prey populations in different densities. The effect of various biotic and abiotic factors on the potential and efficacy of predators was also determined. *M. bastiani* predated maximum when the ratio of predaators in relation to prey has reached at optimum level. The predator prey ratio varied for both species to prey nematodes. The ratio was more in case of the second stage juveniles of *M. incognita* than the adults of *H. oryzae*. The reason could be attributed to the size and activity of prey and also to the fact that the second stage juveniles escaped from the attacks of predators by invading the plant roots. Temperature, prey density, soil type, starvation of predators and soil moisture governed predation by *M. bastiani*

Need for Mass Production of Biocontrol Agents for the Management of Nematodes in Horticultural Crops

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Commercial cultivation of horticultural crops has gained importance because of their increasing value in exports and domestic markets. Monocropping of these crops increased the nematode populations to an alarming dimensions. Plant parasitic nematodes have become one of the major limiting factors in horticultural crop production systems. Country wide concerted efforts to evolve nematode control measures have resulted in development of technologies including chemical control schedules, tolerant varieties and other cultural practices. However, there is a need to promote the use of promising biocontrol agents for the sustainable bio-management of the nematodes in the back drop of environmental problems and other problems associated with nematode resistance breeding. Root-knot nematode (*Meloidogyne* spp.) are most important group of nematodes attacking various horticultural crops. The magnitude of damage and the extent of losses will be very high particularly in disease complexes where these nematodes are associated with pathogenic soil borne fungi and bacteria. Efforts were made to mass produce biocontrol agents such as *Paecilomyces lilacinus, Trichoderma harzianum,* using wheat bran, neem cake, saw dust, coir pith, neem cake suspension and molasses and combinations of these organic products. All these products supported the growth of these bioagents. However, combinations of wheat bran, neem cake and molasses and neem cake suspension were found to be most useful for mass production of these bioagents.

Trichoderma harzianum and *Gliocladium virens* Soil Application, for the Management of Rice Root-Knot Nematode.

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An improvement in the plant growth of paddy var. Rajshree was recorded when fungus *Trichoderma harzianum* or *Glioladium virens* was applied in soil @ 4 g and 8 g per kg. soil, one week prior to the inoculation of *Meloidogyne graminicola*. Pre-nematode fungus application in both doses, significantly reduced the number of galls on root system and larval penetration when compared to nematodes inoculated check. Application of either *T. harzianum* or G. virens @ 8 g/kg soil one week after the nematode inoculation was effective in increasing rice plant growth. Post-nematode fungus application also resulted in reduction of gall formation on root system juvenile penetration inside rice root and final nematode populatin in soil was also significantly decreased in all treatments as compared to check in post nematode fungus application experiment.

Screening of Flowers of Various Medicinal and Aromatic Plants for their Nematicial Activities

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In-vitro tests were conducted to determine the nematicidal potential of aqueous extracats of flowers of various medicinal and aromatic plants against root-knot nematode, *Meloidogyne incognita*. Maximum mortality of the nematode was observed at highest concentration in the aqueous extracts of *Tagetes minuta* and *Rosa damascena* flowers. A strong inhibitory activity was also observed in *Callistmone lanceolata*, *Cymbopogon martinii, Lantana camara* and *Cassia lanceolata* flower extracts. With the decrease in extract concentration there was an increase in mobility of the nematode. Exposure time played an important role in the mortality of the nematode.

Effect of Different Neem Products as Seed Treatment and Soil Application on Growth of Carrot Against Root-Knot Nematode, *Meloidogyne incognita*

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An experiment was conducted during rabi, 1997 to evaluate the efficacy of different neem products as seed treatment individually as well as in combination with soil application on carrot var. 'Early Nentes' against root knot nematode in opaque polythene bag of 30 cm long and 15 cm dia containing 1.75 kg. of sterilized soil. Results revealed that all the treatments significantly increased the plant height, fresh weight of shoot and root, length of tap root and decreased the number of galls per plant over untreated control. Among the treatments, combination of seed treatment with achook @ 1 per cent + NCU increased all the growth parameters of carrot as well as reduced the number of galls on carrot significantly followed by multineem @ 1 per cent + NCU and neemazol F 1 per cent + NCU. However, it is evident from the results that combined application of neem products is more effective than that of applied alone.

Fungi Associated with Root-Knot Nematode Infected Vegetables around Yamuna-River Belt in Delhi

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An extensive survey for disease complex studies in vegetables was conducted in the month of August around Trans-Yamuna river belt of Delhi. Soil and root samples were collected from patchy fields of brinjal and tomato crops. Examination of roots of brinjal and tomato showed heavy infestation of root-knot nematode. The soil on examination was found to be very heavily infested (15 larvae/g of soil) with *M. incognita* while the fungal flora through soil dilution technique and also through isolation of egg-masses (EM) on Potato dextrose agar medium revealed consistent association of a number of fungi i.e., *Aspergillus fumigatus* (soil), *A. terreus* (soil), *A. flavus* (soil), *A. nidulans var. dentatus* (EM), *Chaetomium abuense* (soil), *Sepedomium maheswarium* (EM) and *Fusarium solani* (pathogenic) from brinjal. However, from tomato also *Fusarium oxysporium f. sp. lycopersici* (pathogenic) was recorded. Thus, in addition to two pathogenic *Fusaria* spp. from both tomato and brinjal crops, a number of bioagents as named above have been recorded.

Association of *Steinernema* Spp. with Seiarid Fly (*Bradysia tritici* (Coq.)) Infesting White Button Mushroom (*Agaricus bisporus* (Sing.)) Langej in Punjab (India)

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Survey conducted for the association of nematodes with Sciarid fly (*Bradysia tritici* (coq,)) yielded the association of *Steinernema* spp. in 22% of the samples collected. The nematode was associated with both juveniles as well as adult flies. The nematode was cultured in vivo and its virulence tested against the fly larvae indicated its potential to cause 32-63% larval mortality after 96 h.

Management of Soil Borne Pathogens by Mycorrhizae and its Multifold Role in Agroforestry

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Agroforestry has much to offer in checking land degradation trend and in providing much needed products viz. food, fibre, fodder, fuelwood, timber, medicines etc. It is also a land use system in which trees and shrubs are grown in association with agricultural crops, pastures or livestock in which there is interaction of ecological, economic and biological nature. One of the major factors responsible for the low productivity of these site-specific agroforestry systems is poor availability of nutrients and soil borne pathogens. Many different plant growth promoting rhizospheres microorganisms have been studied intensively because of their potential impact on productivity. Among microorganisms the endomycorrhizae (VAM) fungi are of considerable current interest. About 95% of tropical species have VAM association.. The potential use of VAM fungi in the management of soil borne pathogens including nematodes has been studied at various levels. Therefore, under agroforestry eco-systems the use P-mobilizing microbes on the tree seedlings, influence on the plant bio growth through the better uptake of nutrients, providing resistance to abiotic stresses and ability to increase the tolerance to invading root pathogens. To meet the challenges in the next millennium for the sustainable agroforestry, the potential of VAM needs indepth studies. The aim of the present investigation was to evaluate to role of VAM fungi in the sustainable agroforestry and management of the soil borne pathogens.

Nematode Management

Effect of VAM (*Glomus fasciculatum*) and Nematicides in Management of *Meloidogyne incognita* on Okra

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The nematode managing potential of VAM, *Glomus fasciulatum* and nematicides when used alone on okra is well established against *Meloidogyne incognita* but studies on their combined application and the resultant impact are meagre. Therefore, a pot experiment involving *Glomus fasciulatum*, nematicides (carbofuran and phorate each @ 1 kg a.i./ha) individually and in combination was conducted under *Meloidogyne incognita* infested conditions in okra. The data recorded 45 days after nematode inoculation revealed significantly high shoot length of okra plants by applying carbofuran in presence of VAM. Fresh root weight also followed the same trend. Fresh and dry shoot weight and dry root weight showed non-significant differences. The managing potential of VAM when applied alone was statistically at par when it was combined with either phorate or carbofuran as reflected from observations recorded on number of galls and egg masses.

Salicylic Acid Root-dip Reduces Root Galling Caused by Root-knot nematode, *Meloidogyne incognita*

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Salicylic acid is known to activate plants own defences against several pathogens prior to infection. Bare root dip treatment of 4 week old tomato seedlings, cv. Pusa Sheetal, with salicylic acid @ 25, 50 and 100 g/ml for 20 min. was found effective against root-knot nematode, *Meloidogyne incognita* (4J2/g of soil). The maximum reduction in root infection (43%), soil population (47%) and fecundity (46%) of nematode was observed at 100 µg/ml. No phytotoxicity was noticed at any of the tested concentration.

Efficacy of Chenopodium and Neem as Nursery Soil Amendment in the Management of Root-Knot Nematode in Hybrid Tomato

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A field trial was conducted for two years to test the efficacy of chenopodium and neem in controlling the root-knot nematode, *Meloidogyne incognita* , in hybrid tomato nursery. Chopped, air dried shoots of *Chenopodium album* and *C.murale* and leaves of neem were added in nursery beds @ 500 g/m^2, one week before sowing. Recommended dose of carbofuran 3G (7g/m^2) and an untreated check were kept simultaneously for comparison. Observations were recorded 35 and 50 days after sowing in August and October sown nursery, respectively. Chenopodium and neem amendment improved plant growth (10 seedling weight) and reduced nematode infection as compared to carbofuran treated or untreated beds. However, number of seedlings in carbofuran treated plots was comparatively more than in any other treatment. The October sown seedlings were transplanted in root-knot infested field. It was revealed that at the end of crop, root-knot index was significantly lower in treated than untreated plants. Chenopodium and neem were as effective in reducing nematode infection as carbofuran.

Management of Root-Knot Nematodes in Banana

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Banana is severely attacked by several plant parasitic nematodes like root-knot, lesion, burrowing, reniform, stunt, etc. Out of these nematodes , root -knot nematodes (*Meloidogyne* sp.) are dreadly attacking banana in Central Gujarat limiting profitable cultivation of the crop both qualitatively and quantitatively. To manage these nematodes through integrated approach comprising nematophagous fungus, Paecilomyces *lilacinus* and nematicide, Carbofuran (CAR), the present field study was conducted during 1995-97. Two years pooled results indicated that lowest RKI (1.78) was recorded in combination of *P. lilacinus* and CAR treatment followed by *P. lilacinus* @ 50 kg/ha (1.91) and *P. lilacinus* @ 25 kg/ha (2.02). Significantly higher banana yield was recorded in PL + CAR treatment with significantly higher plant height and highest growth score followed by CAR and *P. lilacinus* higher dose. While control plots had significantly lower banana yield with maximum RKI.

Effect of Root-Knot Nematodes, *Meloidogyne incognita* and *M. javanica* Pathotype-1 on Physical Status of Banana

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The root-knot nematodes, Meloidogyne spp. are predominant and causing 20.60 % yield loss in banana in Gujarat. Present study was carried out to know the effect of Mi and Mj pt.1 infection on meteorological parameters in banana cv. Basrai. Tissue cultured banana plants raised in pots were inoculated @ 100, 1,000, 5,000, 10,000, 50,000 and 1,00,000 J2 of Meloidogyne incognita and Meloidogyne javanica pt.1 /plant separately with check Leaf temperature and transpiration rate increased as inoculum level increased and it was significantly higher in plants inoculated with 1,00,000 J2 of M. incognita or M. javanica pt.1/plant over other treatments. Diffusion resistance rate showed negative relationship with level of inoculum.

Nematicidal Effect of Malathion on Root Knot Nematodes on Brinjal (*Solanum melongena* L)

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Root-knot nematodes are ubiqutious in nature and cause significant damage to vegetable crops including brinjal. As some of the nematicides have been withdrawn from the world market due to health hazards, high cost and pollution of environment and underground water. The present studies were, therefore, carried out to observe the effect of Malathion, fresh leaf extracats of Congress grass and Neem on the root-knot nematodes on brinjal. Forty days old seedlings of brinjal sown in sterilized sandy loam soil were dipped in fresh leaf extracts of Congress grass, fresh leaf extract of Neem, 0.3% Malathion and sterilized water for half an hour before transplanting in the naturally infested sick field with root knot nematodes. The seedlings dipped in the sterilized water were kept as uninoculated control. Each treatment had three replications. Observations regarding shoot and root length, shoot and root weight, chlorophyll contents of leaves, multiplication of root knot nematodes in soil as well as in roots were recorded after 50 days of transplanting. It has been observed that malathion @ 0.3% showed 50% more reduction in nematodes as compared to other treatments over uninoculated control. The observations also showed that flowering and setting of fruits were early and enhanced with 0.3% Malathion as compared to other treatments. The count of bacteria, fungi and actinomycetes was not affected by any of the above treatments.

Combined Effect of Nematicidal Seed Dressing and Organic Amendments for the Management of Root-Knot Nematode, *Meloidogyne incognita* on Carrot

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A field experiment was carried out during rabi, 1997 to evaluate the effect of combination of seed dressing with nematicide followed by application of organic amendents for the management of root-knot nematode on carrot var. Early Nentes'. The experiment was laid out in a naturally infested field with an initial population of *Meloidogyne incognita* 548 J2 of per 250 ml soil. Altogether seven treatments i.e. seed dressing with carbosulfan 25 STD @ 1 per cent (w/w) alongwith application of organic amendment vi. Poultry manure, neem cake and mustard oil cake @ 0.5 and 1 ton /ha each separately including untreated control were laid out in a randomized block design with three replications. The results revealed that all treatments incrased plant growth and yield attributing characters of carrot as well as decreased the nematode population in soil significantly over untreated conrol. However, among the treatments seed dressing with carbosulfan 25 STD @ 1 per cent + mustard oil cake followed by neem cake or poultry manure @ 1 ton/ha separately increased the plant height, tap root length, number of healthy tap root and yield of carrot while decreased the number of forked tap root system as well as final nematode population of soil significantly.

Management of Root-Knot Nematode *Meloidogyne incognita* on Soybean Crop.

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A field experiment was conducted during 1997-98 at farmers field, Kanpur to control *Meloidogyne incognita* on soybean crop. The treatment solarization + carbofuran @ 0.3 g/m2 proved best for getting the highest yield of soybean crop. It was closely followed by another combination i.e. solarization + neem cakes (200 g/m2). The single treatments applied, besides the above mentioned treatments have also minimized the root galling of the crop when observed at the end of the crop. The coorelation study of this experiment also revealed the fact that the solarization done by covering seed bed with polythene sheet or with soil application of carbofuran @ 0.3/m2 (as combination) proved most effective management measures for enhancing the grain yield as well as reducing the gall formation.

Management of Lesion Nematode (*Pratylenchus thornei*) On Chickpea (*Cicer arietinum*) with Oil-Cakes and Nematicides

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Experiments were conducted in *Pratylenchus thornei* infested farmer's field (140-560/500 g soil) on management of the lesion nematode, *Pratylenchus thornei* on chickpea. Four oil cakes viz. neem,mustard, mahua,linseed (at 1 ton/hect.) and two chemicals viz. carbofuran 3G and phorate 10 G (at 2 kg a.i./hect) crop were applied in nematode infested fields. The oil-cakes and nematicides were applied at 15 days before sowing and at the time of sowing respectively. Observations were recorded at 45, 90 and 105 days after sowing on *Pratylenchus thornei* population in soil and in roots. It was observed that all oil cakes and chemicals reduced the pest population in both soil and chickpea roots. The reduction in nematode population in oil cakes was in the order neem > linseed > mahua > mustard > control; and in pesticides was in the order Carbofuran > phorate > control.

Effect of Systemic Nematicides and Plant Products alone and in Combination for the Management of Root-Knot Nematode *Meloidogyne Incognita* on Tomato

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An experiment was conducted under greenhouse conditions with systemic nematicides like carbofuran 200 ug/g, triazophos 200 ug/g, Neem cake, Neem shield, (Neem based fertilizer) and cotton seed cake (all 3% w/w) alone and in combination for the management of root-knot nematode on tomato (cv. Pusa ruby). The plant products were mixed with soil in 30 cm diameter pots infected with *M.incognita* @ 2 J2/g of soil fifteen days before transplanting. Four weeks old healthy tomato seedling was transplanted singly to each pot. Observations on plant growth parameters were taken 60 days after transplantation. In general, all the treatments were effective in controlling the nematode and increasing the plant growth. Carbofuran 100 ug/g in combination with neem cake 1.5% w/w was however, found to be the most effective treatment. Cotton seed cake 3% w/w application was found to be least effective.

Integrated Control of Sugarcane Nematodes in Infested Field

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Carbofuran and phorate were used in nematode infested field of sugarcane @ 1 kg a i /ha at the time of planting, at earthing up and in two split doses, ½ kg a.i./ha each at planting and earthing up in pressmud as well as without pressmud applied plots for the control of nematodes. Application of pressmud one month before planting increased the effect of carbofuran and phorate in reducing nematode population and increasing growth characters including yield and CCS as against untreated plots. Carbofuran and phorate either 1 kg a.i./ha at planting only or in split doses i.e. 0.5 kg a.i./ha each at planting and earthing up gave similar effect. In pressmud applied plots these treatments were found to reduce nematode population by 35.0 to 70.5 per cent and increase in yield by 32.2 to 44.5 per cent. Sucrose per cent and CCS were also superior. While in without pressmud treated plots 2.3 to 29.5 per cent decrease in nematode population and 6.7 to 24.5 per cent increase in yield were recorded in these treatments.

Plant Parasitic Nematodes Infesting Lathyrus (*Lathyrus sativus* L.) and their Management

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Plant parasitic nematodes namely species of *Tylenchorhynchus, Helicotylenchus, Pratylenchus, Meloidogyne* and *Rotylenchulus* were found dominating aroud the rhizosphere of *Lathyrus sativus.* Pathogenicity of *T. mashhoodi, Hoplolaimus indicus* and mixed population of *Tylenchorhynchus, Hoplolaimus, Helicotylenhus* and *Pratylenchus* were successfully established and found pathogenic to *lathyrus.* Initial population of 100 individuals of all stages of *Hoplolaimus indicus* and 1000 of *T. mashhoodi* and mixed population were found at potential pathogenic levels. Losses in growth characters were found directly proportional to the initial population densities of different nematodes. Reduction in growth attributes varied from 12.3 to 55.7 due to *T. mashhoodi*, 11 to 64.5 due to *H. indicus* and 10.5 to 44 per cent due to mixed population at different inoculum levels. *H. indicus* caused maximum loss. All the treatments, either seed dressing, seed soaking or soil treatments with different chemicals were superior in comparison to untreated control in respect of increasing growth characters including bacterial nodules as well as reducing nematode population. Carbosulfan 3% as seed dressing, monocrotophos 0.1% as seed soaking and phorate/carbofuran @ 1 kg a.i./ha as soil treatment were found effective in reducing nematode population and increasing growth characters. Soil treatment with carbofuran/phorate were most effective among all.

Effect of *Glomus Etunicatum*, Padan and Sebufos on the Root-knot Nematode, *Meloidogyne incognita* and Plant Growth of Okra

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Investigation on the effect of *Glomus etunicatum* (1 chlamydospore/g soil, applied at sowing of okra cv. A 4), padan (50 SP) and sebufos (10 G) @ 0.3, 0.7 and 1.5 kg a.i. /ha applied at sowing was carried out alone and in combination on the root-knot nematode *Meloidogyne.inconita* multiplication after 3 months of sowing. Experiment was carried out in completely randomise design in 15 cm. earthen pots with an inoculum of one second stage juvenile/g of soil. Results revealed that padan 0.7 and 1.5kg/ha reduced the seed germination of okra by 50-60%. Observation on the number of galls indicated that sebufos along with VAM fungi showed root-knot indices of 5 i.e. number of galls were above 100 at highest dose of chemical, while sebufos alone reduced the number of galls (below 5 root-knot index), number of egg mass and number of egg/egg mass. Similar observation was recorded for padan alone and combined treatments. In contrast, shoot length, shoot weight and root weight improved by VAM in combination with chemical compared to VAM and chemical treatment alone. This suggested that VAM played negative role against chemical treatment for root-knot nematode multiplication, which however, is positive on the growth of okra plant. The colonization of VAM was affected negatively with the increase of sebufos doses i.e. it reduced to 25% from 75% in sebufos (0.3-1.5 Kg a.i./ha) whereas in case of padan, colonization of VAM fungi was recorded to be around 50% in relation to 60% in inoculated check.

Control of Root-Lesion Nematode, *Pratylenchus coffeae* in Certain Cultivars of Banana

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The root-lesion nematode, *Pratylenchus coffeae* is considered to be one of the economically important nematode pests of banana next only to the burrowing nematode, *Radopholus similis*. The symptoms on roots of banana caused by *P. coffeae* are similar to those of *R. similis*. Both the nematodes are closely associated with the black head toppling disease of banana. The general decline in growth, vigour and delay in flowering are the common symptoms observed in all the banana cultivars. As the studies were not carried out to control the root-lesion nematode infestation on banana, a field experiment was conducted on three commercial cultivars of banana viz., Karpuravalli, Monthan and Nendran at NRCB Farm, Podavur, Trichy by using three chemicals viz. Monocrotophos, Furadan and Bavistin in different doses at different period of application. Results revealed that all chemicals applied in different period were found to be effective in reducing the nematode population and subsequently increase the plant growth characters and yield when compared to untreated control. Application of Furadan @ 50

g/plant one at the time of planting in the pit or mud slurry and sprinkle with Furadan @ 50 g/sucker and two applications after planting at 3 monthly intervals were found to be very effective in reducing the nematode population and significantly increase the yield of 28.75 kg., 22.3 kg. and 9.9 kg. with regard to Karpuravalli, Monthan and Nendran compared to respective untreated control (18.25 kg., 15.10 kg. and 4.25 kg.).

Effectiveness of Phenamiphos for Management of *Heterodera cajani* in Pigeonpea

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A field experiment was conducted for three years during 1995-99 for testing effectiveness of phenamiphos for management of *Heterodera cajani* in pigeonpea using 1.5, 2.0, and 2.5 kg/ha doses in pigeonpea cvs. BDN-2 and GT-100. Results indicated nonsignificant differences in various attributes of both the varieties but different doses of phenamiphos gave significant effect on plant height, grain yield and reduction of final cyst population in soil, over control. The effectiveness was observed to be increased with increase in the dose of phenamiphos. Though all the doses were effective, the highest dose of 2.5 kg/ha was found most effective.

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