Study of diversity of plant parasitic nematodes associated with important summer annuals under temperate conditions in Srinagar, Kashmir

Huzaifah Ashaq
(MSH-2018-197)

Division of Entomology

Faculty of Horticulture

Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir

2021

Study of diversity of plant parasitic nematodes associated with important summer annuals under temperate conditions in Srinagar, Kashmir

Huzaifah Ashaq
(MSH-2018-197)

Thesis

Submitted to

The Faculty of Horticulture

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
in partial fulfillment of requirements for the award of the degree of

Master of Science in Horticulture

(Entomology)

2021

Dedicated TO…

My Beloved Parents who are my spine, My Family, friends and advisor for their love, endless support, encouragement & sacrifices.

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Faculty of Horticulture, Division of Entomology

Certificate – I

This is to certify that the thesis entitled, **"Study of diversity of plant parasitic nematodes associated with important summer annuals under temperate conditions in Srinagar, Kashmir"** submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science in Horticulture (Entomology),** to the **Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir** is a record of bonafide research work carried out by **Ms. Huzaifah Ashaq (Regd. No. MSH-2018-197)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that any help or information received during the course of investigation has duly been acknowledged.

(Dr. Gh. Mohd. Lone)
Chairman
Advisory Committee

Endorsed

Prof. & Head,
Division of Entomology

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Faculty of Horticulture, Division of Entomology

Certificate – II

We, the members of the Advisory Committee of **Ms. Huzaifah Ashaq (Regd. No. MSH-2018-197)** a candidate for the degree of **Master of Science in Horticulture (Entomology)** have gone through the manuscript of the thesis entitled, **"Study of diversity of plant parasitic nematodes associated with important summer annuals under temperate conditions in Srinagar, Kashmir"** and recommend that it may be submitted by the student in partial fulfilment of the requirements for the award of the degree.

Advisory Committee

Chairman

Dr. Gh. Mohd. Lone
Professor & Head,
Division of Entomology,
Shalimar, SKUAST-K

Members

Dr. Rizwana Khursheed
Assistant Professor,
Division of Entomology,
SKUAST-K

Dr. Imtiyaz Tahir Nazki
Professor,
Division of FLA, SKUAST-K

Dr. M. S. Pukhta
Professor,
Division of Agri-Statistics,
SKUAST-K

Dr. S. S. Pathania
Assistant Professor,
Division of Entomology,
SKUAST-K

Dr. Syed Zameer Hussain
Associate Professor,
Division of Food Science and Technology,
SKUAST-K
(Dean's Nominee)

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Faculty of Horticulture, Division of Entomology

Certificate – III

This is to certify that the thesis entitled, **"Study of diversity of plant parasitic nematodes associated with important summer annuals under temperate conditions in Srinagar, Kashmir"** submitted by **Ms. Huzaifah Ashaq (Regd. No. MSH-2018-197)** to the **Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir** in partial fulfilment of the requirements for the award of the degree of **Master of Science in Horticulture (Entomology)** was examined and approved by the Advisory Committee and External Examiner on …….

Chairman
Advisory Committee

External Examiner
Dr. Rajan Salalia
Sr scientist, Nematology
Div of PBG, SKUAST-Jammu

Prof. & Head,
Division of Entomology

Dean,
Faculty of Horticulture
SKUAST-Kashmir

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Faculty of Horticulture, Division of Entomology

Name of the student	:	**Huzaifah Ashaq**
Registration No.	:	MSH-2018-197
Major subject	:	Entomology
Minor subject	:	Floriculture
Major advisor	:	**Dr. Gh. Mohd. Lone** Professor & Head, Division of Entomology, Shalimar, SKUAST-K
Title of the Thesis	:	**Study of diversity of plant parasitic nematodes associated with important summer annuals under temperate conditions in Srinagar, Kashmir**

ABSTRACT

The present investigation was carried out in Nematology Laboratory at Division of Entomology Faculty of Horticulture SKUAST-K, Shalimar during 2020 entitled "**Study of diversity of plant parasitic nematodes associated with important summer annuals under temperate conditions in Srinagar, Kashmir"**. Plant parasitic nematodes form an important component of soil ecosystem and present study revealed six plant parasitic nematodes *viz., Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *Xiphinema insigne, X. americanum* and *Pratylenchus* spp. were found harbouring the rhizosphere of summer annuals in four gardens (*viz;* Chashma Shahi, Nishat, Pari Mahal and Shalimar) of Kashmir valley. In all these four gardens, *Helicotylenchus* spp. was the nematode with widest host range, showing its presence on all ten flowers followed by *X. americanum* and *Tylenchorynchus* spp. *Helicotylenchus* spp*.,* showed 100% frequency on *Dahlia* spp., and *Petunia* spp., followed by 91.66% frequency on *Aster* spp., *Amaranthus* spp., *Celosia* spp., *Gomphrena* spp., *Salvia* spp. and *Zinnia* spp. *Tylenchorhynchus* spp., showed 100% frequency on *Amaranthus* spp., *Tagetes* spp. and *Zinnia* spp. followed by 91.66% frequency on *Aster* spp., *Celosia* spp., *Dahlia* spp., *Impatiens* spp., *Petunia* spp. and *Salvia* spp. *X. americanum* showed 100% frequency on *Gomphrena* spp. while *Trichodorus* spp. showed 100% frequency on *Zinnia* spp. Among the nematodes on each flower, highest absolute density of *Helicotylencus* spp. was found on five flowers

viz *Dahlia* spp. (86.9), *Salvia* spp. (86.5), *Celosia* spp. (61.6), *Aster* spp. (47.4) and *Impatiens* spp. (45.7). *Tylenchorhynchus* spp., showed the highest absolute density on *Petunia* spp. (88.1), followed by *Amaranthus* spp. (51.9) and *Tagetes* spp. (44.6). *X. americanum* showed the highest absolute density on *Gomphrena* spp. (81.5) while *Trichodorus* spp. showed maximum density on *Zinnia* spp.(70.3). Among the above mentioned plant parasitic nematodes, the highest total biomass was found of *Xiphinema americanum* on *Gomphrena* spp. (130.4). Moreover, the maximum importance value was also showed by *X. americanum* on *Gomphrena* spp. (138.9) followed by *Tylenchorynchus* spp. on *Amaranthus* spp. (106.1). The high population of these plant parasitic nematodes were encountered around the rhizosphere of summer annuals and can be considered as a contributing factor in declining health of these flowers and decrease in aesthetic value. Besides, some plant parasitic nematodes *viz*; *Xiphinema* act as vectors for transmission of viruses and thus needs future study.

Keywords: Absolute densities, summer annuals, Kashmir valley, Plant Parasitic Nematodes, Rhizosphere.

Signature of Student
Dated: _____

Signature of Major Advisor
Dated: _____

Acknowledgement

"In the name of Almighty, "Allah", the most Beneficent and Merciful, peace and blessings be upon Holy Prophet (saw). I bow in reverence to Almighty for giving me enough courage, patience and success in this venture"

This thesis couldn't have been accomplished without a great deal of guidance and support –both mental and practical. I would like to thank those people, who, during the several months of my work stood beside me and helped me with everything I needed.

It is indeed a good honour and pleasure for me to express my deep sense of gratitude and indebtness to my major Advisor, Dr. Gh. Mohd. Lone (Professor & Head, Division of Entomology). His soft and sober attitude, inspiring guidance, whole hearted encouragement, facile suggestions and constructive criticism with a calm exposure, led this uphill task to its successful completion and shall remain a lifelong gifted memory for me.

I am highly grateful for constant and painstaking guidance, encouragement, suggestions and sustained efforts of the other members of my advisory committee viz., Dr. S. S Pathania (Assistant Professor, Division of Entomology), Dr. Rizwana Khursheed (Assistant Professor, Division of Entomology), Dr. Imtiyaz Tahir Nazki (Associate Professor, Division of FLA), Dr. M. S Pukhta (Professor, Division of Agri-statistics) and Dr. Syed Zameer Hussain (Associate Professor, Division of food science and technology).

It is a huge opportunity to offer my sincere thanks to Dr. A. A. Khan (Professor, Division of Entomology, Shalimar, SKUAST-K), Dr. Muneer Ahmed sofi (Assistant Professor, Division of Entomology, Shalimar, SKUAST-K), Dr. Abu Manzar (Associate Professor, Division of Entomology, Shalimar, SKUAST-K), for their timely support, encouragement, suggestions, positive criticism, affection and morale uplift.

With utmost gratitude, I would like to place on record the help extended by the staff members of Division of Entomology, FOH Shalimar namely Mr. Naseer ahmad, Mr. Bilal ahmed, Mr. Sajad ahmed, Mr. Reyaz ahmed, Mr. Arjumand, Mohd. Ayoub, Mr. Ghulam Rasool, Mohd Hafeez and Mr. Zahoor.

My special thanks from the core of my heart to my seniors, Mr Waseem, Mr Danish, Ms Iram, Ms Saba, Ms Jasra, Ms Azra and Ms Iqra. I would also like to thank my loving friends Ms Rashiba, Ms Sanna, Ms Tabina and Mr Azhan for their continous support and rooting for me through thick and thin.

I also take this opportunity to express my gratitude to my parents, who put me above their own selves and taught me how to work hard by working hard themselves, my sister Ms. Aalima whose love and affection for me surpassed all worldly definitions and made me feel at zenith of existence and my grandfather and grandmother who have always prayed for my safety and prosperity.

Special thanks from the core of my heart goes to ARIS, Shalimar and Library staff members of SKUAST- K Shalimar for their timely guidance, support and encouragement.

Huzaifah Ashaq

Place: Shalimar, Srinagar
Dated:

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Chapter 1

INTRODUCTION

Floriculture is an activity with immense potential for generating remunerative self-employment among small and marginal farmers and earning of foreign exchange. Floriculture is getting attention globally due to change in the lifestyle of people, concern for environment, conscious efforts towards greening and better purchasing capacity of people. The aesthetic value of flowers and ornamental plants, their use in social events, overall satisfaction in working with them and high income generating power are attracting modern entrepreneurs to invest money in the floriculture industry.

India is the second largest flower grower by area after China. Tamil Nadu is the leading producer of loose flower closely followed by Karnataka both in terms of area and production (Gowda, 2005). India's present contribution in the global floricultural export market is negligible (about 0.6%) as compared to other countries. The domestic industry is growing at an impressive annual rate of 7-10%. Flower crops are estimated to cover around 2.48 lakh ha area with the production of 16.58 lakh tonnes of loose flowers and 4.84 lakh tonnes of cut flowers (Anonymous, 2005). The floriculture in J&K has increased tremendously, which is evident from the increase in area from 255 ha in 2015-16 against only 80 ha in 1996 (Sheikh *et al*., 2015).

Gardening which was only an art and science in the earlier days has now emerged as a huge industry. With the importance and need of gardening in improving and conserving the environment being strongly felt now, the concept of landscaping and gardening is growing rapidly. Ornamental gardening and landscaping has expanded as a multi-faceted industry encompassing activities such as propagating and rearing ornamental plants, landscaping, production of growing media, pots and other accessories, etc., generating huge employment opportunities and simultaneously promoting activities that would improve the

environment. The gardens laid out during the rule of Mughal Emperors in India are called as *Mughal Gardens*. Babar was the first Mughal ruler to introduce this style in India (Randhava, 1986).The main features of Mughal gardens are walls, gates, terrace, running waters, baradari, tomb or a mosque. The 4 Mughal gardens in Srinagar, Kashmir are Nishat, Shalimar, Chashma Shahi and Pari Mahal.

In Jammu and Kashmir, the northern most state of India, tourism has been identified as an industry with potential of development next to agriculture and horticulture. The year 2011 has made history in terms of surpassing all previous records of tourists and pilgrim arrivals in the state. It is estimated that almost 13 million tourists visited J&K in 2012 which placed J&K on 17th position where as Andhra Pradesh is ranked no.1 in the list of major tourist destinations of India (Audil-khaki *et al*., 2016). It can be said that Mughal gardens have an excellent potential of flourishing tourism industry in Kashmir.

The ornamental flowers are the permanent feature of any garden.The proper introduction of annual flowering plants in the gardens add immensely to their decorative value, whether these are large public gardens or a small private garden. Annuals provide a good fragrance and a beautiful display of colour in the garden. They can be grown in ground or as pot plants. Annuals complete their life cycle within a season. As per season, annuals are categorized as winter annuals, summer annuals and rainy season annuals. The sowing of summer annuals in Kashmir begins from 2nd week of May and they bloom upto November. Some of the important summer anuuals planted in the Mughal Gardens of Kashmir are Marigold, *Zinnia*, Gomphrena, Aster, Amaranthus, Salvia, Dahlia etc.

Nematodes are the unsegmented worms of the phylum Nematoda, having elongated, cylindrical and bilaterally symmetrical body. They are more commonly called as roundworms. Nematodes are one of the major pests of highly valued agricultural crops, including vegetables, ornamentals, fruit trees and weeds, especially in the tropical and subtropical countries (Luc *et al*., 2005). Plant parasitic nematodes attack almost all kinds of ornamentals grown in modern

landscape industry, home garden and protected and open-field cultivation (Borgohain, 2016). They are highly diversified organisms and all of them are not distributed equally well everywhere. Many biotic and abiotic factors, such as soil temperature, soil moisture, soil type, cultural practices followed, weed hosts, intercropping, nematode species characteristics, etc. influence the distribution dynamics and shift in population densities of nematodes (Anwar *et al.*, 1991).

The role of nematodes in the life of ornamental plants is complex, manifold, and not fully studied yet. Even randomly selected data show that a number of parasitic nematode species belonging to the genus Ditylenchus, Meloidogyne, Aphelenchoides, Pratylenchus, Rotylenchus, Paratylenchus, Tylenchorhynchus, Tylenchus and some other are capable of causing significant damage to flowering and ornamental plants, especially during the period of growing of the planting material at seedbeds, greenhouses, and growth rooms (Sigariova and Karpliyk, 2015). The nematode damage to plants usually occurs as mechanical deformation of cells and tissues, physiological transformation of parameters, inoculation of fungal and bacterial microbial flora, transmission of viral infections, and disturbances of the symbiotic linkage to the mycotic fungi, and others (Hubin, 2013).

The common feature of growing major ornamental crops is monoculture which provides congenial environment for one or the other nematode species. The nematode population, if unchecked increases to an alarming high level and may finally wipe out the whole crop. Nematodes at low population levels render the planting material like bulb of tuberose and gladioli unmarketable. The infested planting materials are potential source of dissemination of nematodes from one area to another. In USA, losses in ornamentals due to nematodes were estimated to the tune of $ 60 million (Hague, 1972).Worldwide losses in ornamental crops due to plant parasitic nematodes are estimated as 11.10 per cent (Sasser and Freckman, 1987). However, in India the losses due to different nematodes in different ornamental crops are not yet available but the association of plant

parasitic nematode in different ornamental crops are reported from various parts of India. (Borgohain, 2016).

In Kashmir, no such work has been carried out despite the huge inflow of flowers from all over the world. In the view of paucity of information regarding the occurance, distribution, population of these plant parasitic nematodes associated with ornamentals, their study is essential for developing scientific and advisory programs for the stakeholders. In this regard, the present research work shall be carried out under the title "**Study of diversity of plant parasitic nematodes associated with important summer annuals under temperate conditions in Srinagar, Kashmir"** with the following objectives

1. Identification of pre-dominant plant parasitic nematodes associated with important summer annuals in Mughal Gardens of Srinagar, Kashmir.
2. Population abundance and distribution of plant parasitic nematodes in Mughal Gardens.

Chapter 2

REVIEW OF LITERATURE

2.1 Identification/incidence

Audrey-Mackenzie (1960) observed root-knot nematode of *Gomphrena globosa* during the study of leaf blight disease of Gomphrena caused by *Alternaria* spp. in California. The roots showed hypertrophy and abundant formation of galls. The nematodes infecting the roots were cultured in nutritive medium. Pure culture of the nematode with numerous eggs were obtained by careful transfers through several successive generations.

Kafi (1963) listed the different identified nematodes associated with various ornamental plants in Pakistan *viz Aphelenchoides* sp., *Paratylenchus* sp., *Tylenchorhynchus* sp. and *Xiphinema americanum* from the rhizosphere of Chrysanthemum sp.; *Aphelenchoides* sp. and *Hemicycliophora* sp. from the roots of *Celosia argentea*; *Pratylenchus* sp. from the rhizosphere *of Hibiscus rosa-sinensis*; *Ditylenchus* sp., *Helicotylenchus dihystera* and *Tylenchorhynchus* sp. from the rhizosphere of *Cynodon dactylon* and *Pratylenchus coffeae* and *Rotylenchulus reniformis* in the roots of *Codiaeum variegatumres*.

Ahuja and Arora (1980) showed the infestation of flowering annuals by root-knot nematode (*M. incognita*) under field and pot conditions on plants belonging to families compositae, verbenceae, cruciferaceae, ongraceae, ranunculaceae, caryophyllacae, solanaceae etc. They reported 100 per cent infestation on all of them by root-knot nematodes in both the conditions.

Krishnappa *et al.* (1980) conducted a survey on plant parasitic nematodes associated with ornamental plants in Bangalore. *Rotylenchulus reniformis* was found on all plants except *Althea rosea, Meloidogyne incognita* galls were found on 12 hosts, *Helicotylenchus crenatus* was found on 10 plants, *Tylenchus* sp. on 4 plants, *Tylenchorhynchus dubius* on 3 plants and *Hoplolaimus indicus* on only *Chrysanthemum* sp.

Maqbool *et al*. (1986) recorded 11 hosts of root-knot nematodes *Meloidogyne* spp. (*M. incognita* Race-1, *M. javanica*) including ornamentals *viz*., cactus (*Opuntia* sp.), ceriman (*Monstera deliciosa*), cock's comb (*Celosia argentea*), dumb cane (*Dieffenbachia seguine*), milkbush (*Euphorbia tirucalli*), purslane (*Portulaca oleRacea*), red spinach (*Amaranthus hybridus*) and spider plant (*Chlorophytum cosmosum*).

Kim *et al.* (1987) conducted a survey of plant parasitic nematodes in fields growing ornamental plants and medicinal herbs. Identification led to nine nematode genera found on 11 ornamental plants species *viz Pratylenchus* sp., *Paratylenchus* sp. and *Tylenchus* sp. were the most pathogenic with number of *Paratylenchus* sp. reaching upto 3500/200cc of soil on carnation.

Sundarababu and Vadivelu (1988) studied plant parasitic nematodes associated with Tuberose in Tamil Nadu, India. Three species of *Meloidogyne viz M. javanica*, *M. incognita* and *M. arenaria* were associated with tuberose.

Khanna and Khan (1990) did a survey for plant parasitic nematode associated with ornamental plants in Solan and Shimla districts of Himachal Pradesh, India. *M. incognita* was recorded as the most prevalent and damaging nematode in eight out of twelve species. *Helicotylenchus vericaudatus* and *Criconemella xenoplax* were the other nematodes found associated with carnation.

Khan and Reddy (1991) reported that *M. incognita* (Race -2), *M. javanica* and *Rotylenchulus reniformis* were the most important pathogens on tuberose in and around Bangalore.

Petit and Crozzoli (1995) carried out a survey to identify the plant parasitic nematodes associated with ornamental crops in Venezuela. Soil and root samples were taken and analyzed. Twelve nematode genera were found associated with carnation, gladiolus, rose, chrysanthemum and anthurium. *Meloidogyne incognita* and *Pratylenchus penetrans* were the most numerous and were widely distributed

Yamamoto and Toida (1995) carried out a survey and found the presence

of *Aphelenchoides* spp., *Criconemella* spp., *Helicotylenchus dihystera*, *Paratylenchus* spp. and *Tylenchus* spp. Although the damage caused by these nematodes to vegetables was not observed, heavy damage of carnation and sweet pea by *Meloidogyne* spp. and of chrysanthemum, by *Pratylenchus* spp. were noted. These two genera of nematodes were considered to be the most harmful to flower crops.

Nagesh and Reddy (1996) reported *Meloidogyne incognita* on carnation and gerbera in commercial polyhouses of Karnataka, India.

Tenete (1996) studied nematode problems of ornamental and vegetable bulbs in controlled conditions. There were many genera of nematodes affecting bulb crops throughout the world. Among them, seven genera were mostly identified *viz Ditylenchus, Heterodera, Longidorus, Meloidogyne, Paratylenchus, Pratylenchus* and *Paratrichodorus.*

Pathak and Siddiqui (1997) conducted a survey to find out the association of nematodes with some ornamental plants. They observed the presence of *Tylenchorhynchus crotoni* in *Croton* sp., *Tylenchorhynchus ewingi* in *Rosa* sp., *Tylenchorhynchus mashhoodi* in *Hibiscus rosa-sinensis*, *Tylenchorhynchus brassicae* in *Nerium odorum*, and *Tylenchorhynchus leviterminalis* in *Rosa* sp.

Baqri (1999) studied the diversity in plant and soil nematodes of West Bengal. He listed various nematode species in the orders of Tylenchida (67 spp.), Aphelenchida (7 spp), Dorylaimida (81 spp.) and Monochida (15 spp.).

Jonathan Eisenback (1999) reported *Meloidogyne petunia* parasitic on petunia in Brazil. Petunia plants that were severely infected were collected from a garden at EMBRAPA/National Research Centre for vegetable crops. All nematode stages used in morphological studies were from stock cultures maintained on petunia plants in green house at 22-28 °C.

Rama and Dasgupta (2000) reported association of *X*iphinema *insigne* with coconut and arecanut in Cooch Bihar and Jalpaiguri and also reported the

association of *Xiphinema elongatum* with coconut in both districts of West Bengal.

Khan and Pal (2001) conducted a survey for occurrence and distribution of plant parasitic nematodes in *Polianthes tuberosa* in West Bengal. It was reported that five nematode species showed incidence *viz., Aphelenchoides besseyi, Meloidogyne incognita*, *Rotylenchulus reniformis, Hoplolaimus* spp. and *Helicotylenchus* spp. *A. besseyi* was recovered from flowering stalks. High populations of *R. reniformis* and *M. incognita* were recovered from the rhizosphere.

Salalia *et al*. (2002) conducted a systematic survey to find the status of Xiphinema spp. associated with perennials and ornamentals in Udaipur, Rajasthan. Two new species were reported around the rhizosphere *viz X. kesarii* which was reported in fig from Horticulture Farm and *X. udaipurensis* which was reported in pomegranate from Krishi Vigyan Kendra.

Barsi and Lamberti (2004) studied the morphometrics of L*ongidorus juvenilis* with brief descriptions, measurements and illustrations of the *L. aethaeus* and *L. moesicus* which were recorded for the first time from Serbia.

Chaudhury *et al.* (2004) while studying the diversity of nematodes in four districts of Assam during 2002-2003 computed on relative density, frequency, biomass and prominence value. The association of thirty-two nematode species as identified belonged to Dorylaimidae and one to Triplonchidae.

Khan (2005) conducted a study under field conditions to assess the effect of root-knot nematode infection on three winter ornamental plants *viz., Althea rosea, Petunia hybrida,* and *Papaver rhoeas.* The three ornamentals were highly susceptible to *M. incognita* with highest incidence on Althea followed by Papaver and Petunia respectively.

Khan and Verma (2005) carried out a survey for assessing the incidence and distribution of Longidorid nematode species in temperate region of Himachal

Pradesh especially the high-altitude zone of the state. It was revealed from the survey results that *Xiphinema slansis, Xiphinema inaequale, Xiphinema insigne, Xiphinema basiri*, *Longidorus citri*, *Longidorus brevicaudatus, Longidorus attenuatus, Paralongidorus microlaimus* and *Paralongidorus neoformis* were found in low to high number. Further, *Paralongidorus neoformis* was found in association with *Ficus carica* L. from Kullu.

Shamashtabrekhan (2005) surveyed and collected soil and root samples revealed the presence of *Helicotylenchus dihystera, Rotylenchulus reniformis, Pratylenchus* spp., *Meloidogyne* spp., *Xiphinema* spp. and other dorylaimid plant parasitic nematodes in carnation and gerbera rhizospheres grown in polyhouses. Of these, *Helicotylenchus dihystera* was found to be the most predominant.

Adekuncle *et al*. (2006) conducted the survey for distribution and abundance of plant parasitic nematodes in Lilium in Himachal Pradesh where moderate (101-500/200cc soil) to high (501-1000/200 cc soil) populations of phytonematodes were recorded.

Deimi *et al.* (2008) conducted a survey in Mahallat, Iran for nematode species in ornamental flowers. About twenty one nematode species from twelve genera were identified. *Aphelenchus avenae* was the most commonly detected species followed by *Helicotylenchus pseudorobustus* and *Pratylenchus thornei.*

Zalpuri *et al.* (2013) carried out studies based on the survey conducted and assessment made by the frequency of occurrence of economically important plant parasitic nematodes associated with *Citrus* crop. Samples were collected from roots and soil rhizosphere from 10 localities representing 3 districts namely Samba, Kathua and Rajouri for the study of nematodes infestations.

Manju and Subramaniam (2015) conducted a survey in the different districts of Tamil Nadu in order to determine the most important plant parasitic nematodes species associated with gerbera. The analysis of soil and root samples collected from the rhizosphere of gerbera in each district revealed the presence of

only five species of plant parasitic nematodes *viz., Meloidogyne incognita, Helicotylenchus multicinctus, Pratylenchus coffeae, Tylenchorhynchus* spp. and *Rotylenchus reniformis*.

Meressa *et al.* (2015) collected soil samples from the rhizosphere of gypsophila and rose plants from greenhouses in Debrezeit and Ziway localities in Ethiopia. Among various nematode species four were identified as new records namely *Mesocriconema sphaerocephaloides, Longidorus laevicapitatus, Paratylenchus obtusicaudatus, and Nanidorus minor.*

Sigariova and Karpliyk (2015) reported the occurance of *Meloidogyne*, *Ditylenchus*, *Pratylenchus*, *Rotylenchus*, *Tylenchorynchus*, *Paratylenchus*, *Helicotylenchus* and *Heterodera* genera on Coleus, Begonia, Dahlia and Asparagus.

Mahdavian and Jahanshahi (2017) collected 170 samples of soil and root from seventy-four ornamental greenhouses plants from different cities of Mazandaran province. About nine genera and 10 species *viz Meloidogyne javanica, Aphelenchoides spp., Ditylenchus dipsaci, Helicotylenchus Scutellonemabrachyurus, Meloidogyne brevidens, Pratylenchus thornei, Pratylenchus vulnus, Paratylenchus and Tylenchulus semipenetrans* were extracted and identified.

Sujata and Sharma (2018) carried out an investigation during the year 2015-16. Soil samples were collected from the rhizosphere of the commercial vegetable crops (pea, potato and cabbage) and fruit crops (apple, apricot and almond) of the tribal district Kinnaur in Himachal Pradesh. Four nematodes *viz*., lesion nematode (*Pratylenchus coffeae*), stunt nematode (*Tylenchorhynchus mashhoodi*), spiral nematodes (*Helicotylenchus dihystera*) and juveniles (J2) of root knot nematode (*Meloidogyne* sp.) were found prevalent in the rhizosphere of all the vegetable and fruit crops, with their considerable population build up.

2.2 Community analysis

Chandel *et al.* (1997) conducted a survey to know the presence of plant parasitic nematodes associated with gladiolus in Solan and Shimla districts of Himachal Pradesh, India. *M. incognita* was recorded as the most frequently occurring nematode, followed by *Helicotylenchus dihystera, Macroposthonia xenoplax* and *Pratylenchus* spp. were the other two nematodes commonly associated with gladiolus.

Sodeuk *et al.* (1998) revealed that 12 species of plant parasitic nematodes *viz.*, *Meloidogyne hapla*, *M. incognita*, *Pratylenchus penetrans*, T*ylenchorhynchus claytoni*, *T. nudus*, *Helicotylenchus pseudorobustus*, *Criconemoides morgensis*, *Ditylenchus dipsaci*, *Discocriconemella hengsungica*, *Hemicycliophora koreana*, *Xiphinema pini* and *Aphelenchus avenae* were associated with the rhizosphere of peony plants. Frequency and density of these nematodes varied in different regions. *Meloidogyne hapla* was found to be the most frequent and prevalent in all the regions surveyed, whereas, high frequency and density of *Creconemoides morgensis*, *Discocriconemella hengsungica* and *Helicotylenchus koreana* was recorded in hilly regions.

Meressa *et al.* (2015) conducted surveys from August to September 2011 (wet season) and April to May 2012 (dry season) to assess the incidence of economically important plant-parasitic nematodes associated with cut-flowers Ethiopia. Soil samples were collected from rose, carnation, gypsophila, freesi and static plants. A total of thirteen nematode taxa associated with these five cut-flower species were recorded *viz*. *Criconemella, Ditylenchus, Helicotylenchus, Hemicycliophora, Longidorus, Meloidogyne, Merlinius, Paratrichodorus, Paratylenchus, Pratylenchus, Rotylenchulus, Rotylenchus* and *Tylenchorhynchus*. *Helicotylenchus* was recovered from all cut-flower species.During the wet season, *Helicotylenchus* was the most frequently encountered genus (77%) followed by *Meloidogyne* (46%). In the dry season, *Meloidogyne* was encountered in 78% of the samples followed by *Helicotylenchus* (33%).

Zaki and Mantoo (2006) conducted a survey in Kashmir valley that revealed the presence of 10 parasitic nematodes associated with rhizosphere of fruits (cherry, walnut, apple, apricot, plum and pear) nurseries and orchard. The nematode population was highest in July and lowest in December; thus, there was a positive effect of ambient temperature, and a negative effect of rainfall and relative humidity on nematode build-up.

Shahina and Musarrat (2006) made a survey on distribution of root-knot nematodes in NWFP and Sindh. 453 samples comprising of 19 species of plants (including vegetables, fruits and ornamentals) were collected. Out of 453 samples, 54% were found to be infected by 2 species *viz Meloidogyne incognita* and *Meloidogyne javanica*.

Oliveira *et al.* (2007) reported that the most frequently occurring plant parasitic nematodes in ornamental plants in Brazil were *Meloidogyne javanica* (38%), *M. incognita* (19%) and *Helicotylenchus dihystera* (11%). They further recorded some new hosts of plant parasitic nematodes *viz*., *M. incognita* in Gloxinia sp., *Arundina graminifolia* and *Aptenia cordifolia*; *M. javanica* in *Arundina graminifolia*, *Hibiscus* spp., *Gloxinia* sp*., Eustoma grandiflorum, Heliconia rostrata, Graptophyllum pictum, Holmskioldia sanguine and Exacum affine; Pratylenchus brachyurus in Eustoma grandiflorum, Cattleya sp.* and different cultivars of *Lilium* sp.; *Helicotylenchus dihystera* in *Eustoma grandiflorum*, *Lilium* sp., *Impatiens balsamina* and *Aptenia cordifolia*; *Helicotylenchus multicinctus* in *Pachystachys lutea*; *Helicotylenchus pseudorobustus* in *Heliconia* sp.; and *Cactodera cacti* in *Schlumbergera* species.

Dias-Arieira *et al.* (2007) recorded highest nematode density of *Meloidogyne* in *Zoysia japonica* and *Helicotylenchus* in *Schlumbergera truncata* and *Hemerocallis flava*. The *Helicotylenchus* spp. were the most frequently isolated, followed by *Tylenchus* spp., *Meloidogyne* spp., *Paratylenchus* spp., and *Pratylenchus* spp. However, *Rotylenchulus*, *Xiphinema*, *Aorolaimus* and *Hoplolaimus* occurred in low frequencies.

Deimi *et al.* (2008) carried out a suvey in which twenty-one nematode species were found associated with ten species of ornamentals cultivated in Mahallat, Iran. Among those twenty-one nematodes, *Aphelenchoides* spp. had 100 % frequency on Calla, *Helicotylenchus* spp. had 100 % frequency on Snapdragon, *Pratylenchus* spp. had 100 frequency on Stock. While on tulip 5 nematodes with 100% frequency each were found *viz Boleodorus* spp., *Helicotylenchus* spp., *Pratylenchus* spp., *P. thornei*, and *Zygotylenchus* spp.

Sen *et al.* (2008) studied the population fluctuation of Helicotylenchus in relation to soil temperature, moisture and pH in guava orchard of West Bengal and found that the maximum population densities of *Helicotylenchus* occurred in the month of June and July and lowest in September, April and May.

Rashid (2008) conducted a survey of the plant parasitic nematodes associated with ornamental plants in AMU campus, Aligarh. Total nine genera of plant parasitic nematodes *viz Aphelenchoides sp., Helicotylenchus sp., Hoplolaimus sp., Meloidogyne sp., Pratylenchus sp., Rotylenchulus sp., Tylenchorhynchus sp., Tylenchus sp. and Xiphinema sp.* were found in 144 soil samples collected from the rhizosphere of ornamental plants. It was recorded that *Helicotylenchus* was found in highest number in field having *Althea rosea* (119/200 cc soil) whereas its lowest density was recorded in Tagetes erecta (20/200 cm^3 soil). The highest *Tylenchorhynchus* was found in *Petunia* (90/200 cm^3 soil) and lowest density was recorded in *Celosia cristata* (10/200 cm^3 soil). The density of *Pratylenchus* was highest (40/200 cm^3 soil) in *Iberis amara* and *Jasminum sambac*. Moreover, *Pratylenchus* was absent in Celosia, *Plumeria alba, Calendula officinalis* and *Salvia splendens*.

Lone (2009) investigated the status of plant parasitic Adenophoreans at Faculty of Agriculture, SKUAST-K, Wadura on apple locality wise in district Baramulla, to study the horizontal distribution of important adenophoreans around apple trees, their seasonal fluctuation and to record the report of known and new species (if any) and the observations revealed the following important

information. Among the various identified plant parasitic Adenophoreans, the most important Adenophoreans were found as *Xiphinema insigne*, *Xiphinema index* and *Longidorus elongatus* in all the localities each with 100 per cent frequency. The study concludes with the findings that adenophoreans are cosmopolitan in apple at orchards of Baramulla district of Kashmir valley.

Nath *et al*. (2009) carried out survey on 15 -20 years old litchi plants and were sampled for qualitative and quantitative analysis of plant parasitic nematode communities. A total of nine species under seven genera were identified from soil and associated root samples of the litchi plants. Out of nine species, *Rotylenchulus reniformis*, *Helicotylenchus indicus*, *Tylenchorhynchus leviterminalis* and *Xiphinema* spp. were new records of association with litchi plants from Tripura state and also from north-east India. Results of the community analysis showed that out of nine plant parasitic nematode species, *Hemicriconemoides litchi, Rotylenchulus reniformis* and *Meloidogyne incognita* were the most abundant, frequent, prominent and important nematode species in all of the four litchi plantations in NorthTripura district. On the basis of total biomass of nematodes, these three species were also abundant and dominant in comparison to other six species. Out of four litchi plantations, Choraibari and Panisagar plantations in Dharmanagar sub-division showed highest species diversity followed by Nabincherra and Chantail plantation.

Abbas and Waliullah (2010) reported that among plant parasitic nematodes, *Meloidogyne*, *Helicotylenchus* and *Pratylenchus* spp. were found to be associated with the roots of gladiolus. Analysis of nematode community of three localities *viz*., Cheshmashahi, Shalimar and Chandpora of Srinagar district of Kashmir Valley revealed that *Helicotylenchus* and *Basiria graminophila* were predominant at Cheshmashahi, while, *Basiria graminophila* and *Xiphinema* at Shalimar and *B*asiria *graminophila* and *Pratylenchus* spp. at Chandpora. The *Rhabditids* and some other free living nematodes were also found in all the three localities in varying numbers.

Sahu *et al.* (2011) carried out community analysis of plant parasitic nematodes in vegetable crops in Durgh district of Chattisgarh, India. The most prominent nematode was *Meloidogyne* spp. associated with tomato, brinjal, cow pea and bottle gourd. The other nematode genera found were *Rotylenchulus, Tylenchoryncus, Pratylenchus* and *Helicotylenchus.* The highest frequency was of *Helicotylenchus* (20.69%) followed by *Meloidogyne javanica* and *Rotylenchulus* (17.2%). *Meloidogyne incognita* showed the highest population density of about 487.5%.

Askary *et al.* (2012) studied the population fluctuation of plant parasitic nematodes associated with pome, nut, stone fruit nurseries (including apple) from three years old nurseries at five different localities *viz*., Sumbal, Shuhama, Wanihama, Gasoo and Arabal in Ganderbal and Srinagar districts of Kashmir valley.and concluded that the population fluctuation in nematodes may be due to the rise and fall in temperature as well as presence of moisture content.

Lone *et al.* (2012) described and illustrated *Xiphinema index*, the dagger nematode from rhizosphere of neglected apple orchards of Baramulla, Kashmir.

Lone *et al.* (2012) carried out a survey on the occurance of virus vector nematodes in different eco-habitats of same age (25-30 years) apple trees and collected four composite soil samples from each of the disturbed, undisturbed and neglected orchards having same altitude. Results revealed that maximum population of the virus vector nematodes per 250 cc soil was from neglected orchards Results revealed that maximum population of the virus vector nematodes per 250 cc soil was from neglected orchards (108.42), followed by from undisturbed orchards (90.42) and comparatively low population (83.58) was recorded in disturbed orchards.

Zalpuri *et al.* (2013) inferred community analysis of plant nematodes is an important criterion for assessment of their pathogenic potential. This investigation involved a study of the community structure of phytonematodes associated with

the *Citrus* plants in the various districts of Jammu, J&K. The predominant nematode species were *Meloidogyne javanica, Hoplolaimus* sp*., Pratylenchus* sp., *Xiphinema* sp. and *Tylenchulus semipenetrans.*

Singh and Kumar (2013) conducted a research on the distribution of plant parasitic nematodes in UP for the assessment of losses caused by them in vegetables. Nematode population densities were determined from 412 root and soil samples collected from vegetable growing areas of UP. The most abundant plant-parasitic nematodes detected along with their frequencies were *Meloidogyne incognita* (82.16%), *M. javanica* (68.42), *Rotylenchulus reniformis* (43.98%), *Xiphinema basiri* (23.45%), *Hoplolaimus indicus* (21.99%), *Tylenchorhynchus nudus* (16.60%), *Pratylenchus zeae* (15.77%), *Heterodera avenae* (7.88%), *Aglenchus costatus* (7.47%), *Tylenchorhynchus mashoodi* (6.64%), *Aphelenchus avenae* (5.39%), *Discolaimus* (4.15%), *Boleodorus similis* (3.32%), and *Tylenchus* (2.07%).

Lone and Zaki (2014) carried out a survey of apple orchards of Kashmir valley and concluded that the nematodes *viz Xiphinema insigne* and *Longidorus elongatus* were found as the most frequent species.

Rashid *et al*. (2014) conducted a survey of ornamental plants in Rajouri district of J&K and recorded the nematode community structure. Nine plant parasitic nematodes were isolated and identified from 217 soil samples collected from rhizosphere of plants. Out of these nine, the highest frequency of occurance was recorded in *Meloidogyne* spp. (76.49%) followed by *Helicotylenchus* (54.83%), *Hoplolaimus* (37.32%), *Rotylenchus* (42.39%), *Tylenchorynchus* (25.03%), *Tylenchus* (19.81%), *Xipinema* (16.58%), *Longidorus* (10.13%), and *Aphelenchoides* (8.75%).

EI-Deen *et al.* (2015) reported plant parasitic nematodes in rose at Taif University, Saudi Arabia. The soil samples were collected from 3 localities. Among the samples collected, four genera *viz* Meloidogyne, Rotylenchus,

Xiphinema and Pratylenchus seemed to be the most prevelant ones occurring at rates of 120, 117, 66 and 45 times with percentage 30 %, 29.3%, 16.5% and 11.3% respectively.

Mahdavian and Jahanshahi (2017) did a research work on nematodes associated with ornamental plants in greenhouse condition in Iran. About 72 ornamental plants and flowers were selected from various locations of Mazandaran province. A total of 170 samples of soil and roots were collected from 2012-2015. About nine genera and ten species *viz Meloidogyne javanica, M. brevidens, Aphelenchoides spp., Ditylenchus dipsaci, Helicotylenchus* spp. *Scutellonema brachyurus, Pratylenchus. thornei, P. vulnus, Paratylenchus* spp. *and Tylenchulus semipenetrans* were extracted and identified. Among them, *Helicotylenchus, Aphelenchoides* and *D. dipsaci* were the mostly occurring nematodes with 25, 20, 15 as frequency percentage respectively. *M. brevidens*, *P. thornei*, *P.vulnus, Scutellonema brachyurus* and *Paratylenchus* had frequency percentage of 4, 3.5, 2, 1 and 0.6 respectively.

Surega and Ramakrishnan (2017) carried out a study in turmeric to determine the community structure of plant parasitic nematodes in Tamil Nadu, India. The dominant nematode species were *Meloidogyne incognita, Pratylenchus delattrei, Radopholus similis, Longidorus elongatus, Xiphinema elongatum, Hoplolaimus seinhorstii, Helicotylenchus multicinctus, Tylenchorhynchus martini* and *Rotylenchulus reniformis.* The root knot nematode *M. incognita* was identified as most frequently occurred nematode and *T. martini* as less frequently occurred nematode in soil with absolute frequency of 72.3 % and 4 % respectively. The absolute density of *M. incognita* was highest in both soil (475) and root (125) while the prominence value was also highest in respect of *M. incognita* in the range of 0 to 47.5 and 0 to 30.9.

Aseffa (2018) carried out a study to determine which nematodes are involved in suppression of growth and death of ornamental plants. A total of ten genera of plant parasitic nematodes *viz Helicotylenchus, Hemicycliophora,*

Meloidogyne, Pratylenchus, Scutellonema, Paratrichodorus, Rotylenchulus, Trichodorus, Mesocriconema and Tylenchorhynchus were recorded associated with those ornamental plant species. *Helicotylenchus* and *Scutellonema* were found associated with all ornamental plants. Moreover, these ornamentals hosted the respective nematodes with varying population densities and frequencies. The highest mean population density recorded for *Meloidogyne* was 130 in Salvia. *Helicotylenchus* became the most abundant among all genera recorded with mean population density of 380 nematodes recorded on Doronicum while the least host for this genus was Colocasia with a population density of 13 nematodes per100 ml soil. Trichodorus, Rotylenchulus and Pratylenchus that were only found in a single sampling site of their respective hosts had generally low mean population density of 17, 13 and 7 nematodes, respectively. The highest frequency of occurrence (100%) of Meloidogyne was recorded on Rose, Colocasia, and Salvia. *Tylenchorhynchus* was detected from three sampling sites (100%) associated with Phoenix spp. *Helocotylenchus* was the most occurring nematode in all the ornamentals with 100% frequency in Aster, Salvia, Colocasia and Doronicum.

Nilambika *et al.* (2018) conducted a study to identify the frequently encountered pathogenic nematode species on the commercial flower crop tuberose. The studies were conducted in Belgaum district, Karnataka. Samples comprising soil and root parts were collected from rhizosphere of flower crops grown in field as well as polyhouses conditions. A total of seven species of plant-parasitic nematodes *viz*., *Meloidogyne, Helicotylenchus, Tylenchulus, Hemicyclophora, Xiphinema, Rotylenchus, and Pratylenchus* were found to be associated with tuberose soil samples. *Meloidogyne* sp. had the highest absolute density of 130 with a 100 percent frequency followed by *Helicotylenchus* spp. with 83.3 percent frequency.

Kumar and Das (2019) conducted a systemic investigation to assess the diversity and community structure of plant parasitic nematodes from the soil rhizosphere of ten different citrus species grown at Citrus Research Station,

Tinsukia, Assam. Four major plant parasitic nematode species *viz*., *Tylenchulus semipenetrans*, *Helicotylenchus dihystera*, *Hoplolaimus indicus* and *Tylenchorhynchus* spp. were found prevalent in the rhizosphere of ten different citrus species. In addition to these, several Dorylaimid, Rhabditid and Predatory nematodes were also encountered. Amongst the plant parasitic nematodes, *T. semipenetrans* was highly abundant (100%) followed by *H. dihystera* (80%), *Tylenchorhynchus* spp. (70%) and *H. indicus* (50%). Among, different citrus species, a higher population of *T. semipenetrans* was encountered on rough lemon and least number was encountered on trifoliate orange.

Chapter 3

MATERIALS AND METHODS

3.1 Survey

Survey was carried out in Mughal Gardens to find out the prevalence of plant parasitic nematodes in the rhizosphere of the summer annuals. Four Mughal Gardens *viz* Shalimar, Nishat, Chashma Shahi and Pari Mahal were surveyed and from each garden, 10 common flowers were selected *viz Zinnia* spp., *Gomphrena* spp., *Dahlia* spp., *Tagetes* spp., *Amaranthus* spp., *Aster* spp., *Salvia* spp., *Celosia* spp., *Petunia* spp. and *Impatiens* spp. From each flower, 3 soil samples were collected and a total of 30 samples were collected from each garden..Selection of prominent locations were made, having same kind of flower species with same colour.

3.2 Collection of soil cum root sample

About 500 cc soil samples, along with 5g roots were collected from each garden from the feeder zone of the flowers. Sampling was done during the flowering season (June to August).The samples were collected manually with the help of khurpi at a depth of 20 cm. The samples were collected in polybags and were tied with rubber band and the samples were labelled and stored in laboratory at a temperature of 7^{o}C.

3.3 Processing of samples for the extraction of nematodes

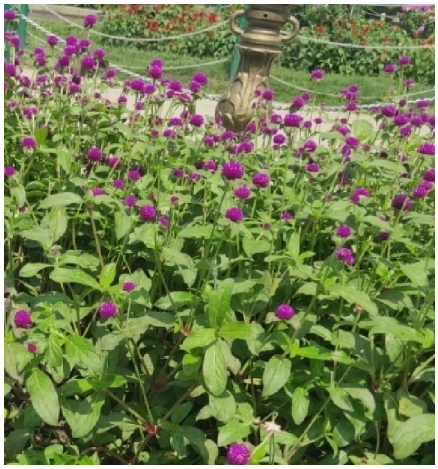
To isolate the nematodes from a composite soil sample, only 250 cc soil was processed by modified Cobb's sieving and decanting technique (Cobb, 1918). For extraction of nematodes a set of sieves were used (18, 60, 100, 200, 300, 400). Then the resultant suspension of each sieve with residue was separately spread on the double layer tissue paper placed on aluminum wire mesh and same was placed on petri-plates containing fresh water/distilled water.

Aster spp.

Amaranthus spp.

Celosia spp.

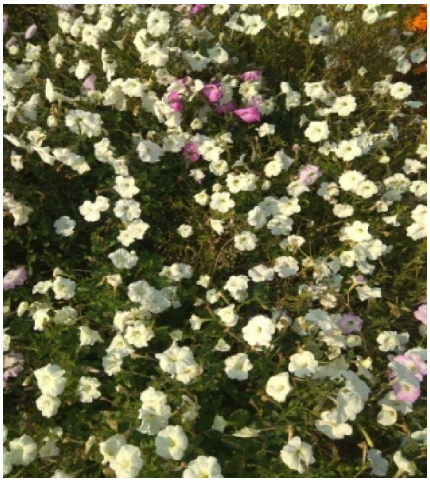
Dahlia spp.



Gomphrena spp.

Plate 1: Important summer annuals

Impatiens spp.



Petunia spp.

Salvia spp.

Tagetes spp.

Zinnia spp.

Plate 2: Important summer annuals

Plate 3: Collection of soil samples

3.4 Killing and Fixing of Nematodes

Nematode suspension from the beaker was taken in test tubes and these test tubes were dipped in metallic container filled with boiling water. Suspension was constantly shaken to apply uniform distribution of heat till all the nematodes were killed. Suspension was fixed with 4 % formaldehyde solution and the volume was reduced to 20ml and then stored in McCartney vials inscribed with host, locality and date of collection.

The roots of flowers were cut into 2-3 cm pieces and mixed thoroughly. Each root cutting was stained with 0.1% acid fuschin lacto phenol (Hooper, 1970) for 30 seconds. Out of the stained roots, 1g root cuttings were studied under stereoscopic microscope using teasing needles.

3.5 Slide preparation

The fixed nematodes were transferred to a small cavity block containing glycerine alcohol mixture (5 parts of glycerine and 95 parts of absolute alcohol) by picking them with the help of broom pick under zoom stereoscopic microscope. The cavity block was placed in desiccator at room temperature for slow dehydration for about 4-5 days. The nematodes were processed gradually into anhydrous glycerine and then were transferred from cavity block in to a drop of dehydrated glycerine on a glass slide and suitable glass wool support was given in the mount to prevent the pressure of cover slip on the specimens. The cover slip was sealed with nail polish from the edges.

3.6 Identification of nematodes

Details of morphological parameters were studied in a population of different nematode genera, taking into consideration the characters viz., shape of lip region/ amphids, odontostylet/ odontophore, shape of oesophagus, guiding ring, nerve ring, post uterine sac, tail shape etc. Measurements on related characters of taxonomic importance were done under a compound microscope.

Such measurements on different morphological features were used to compute deMan's ratios such as a, b, c, v' etc., in order to differentiate one species with another.

3.7 Counting of Nematode Population

The nematode suspension isolated from the sample was observed under zoom stereoscopic microscope in a counting dish for the identification of plant parasitic nematode genera and to count their population densities. The number of nematodes were counted in one ml of nematode suspension (after thorough bubbling) with the help of a counting dish and an average of five such counts were taken as the number of nematodes per ml. The volume of the suspension was multiplied with average count of nematodes per ml to estimate total number of nematodes per 250 cc of soil sample.

3.8 Photo micrograph of Nematodes

Photographs of nematodes from permanent slides were taken through the micrographic camera fitted to Leica microscope, model DMLB with 40x resolution.

3.9 Calculation of data

Population density and frequency of occurrence of each nematode genus/ species was determined at each location and for total samples collected from the particular area. Nematodes communities were analyzed on having prominence value and importance value for each nematode genus/species (Norton, 1978; Waliullah, 1983). Biomass was determined on having the measurement on length and width of nematodes collected from each location/district.

In order to study on the nematode community structure with reference to relative frequencies, relative densities, prominence value, biomass and importance value of nematodes, the formulae proposed by Norton (1978) is as under:

1. Absolute frequency of sp./genus x = $\frac{\text{No. of samples containing species/genus}}{\text{No. of samples collected}} \times 100$

2. Relative frequency of sp./genus x = $\frac{\text{Frequency of species/ genus}}{\text{Sum of frequencies of all spp/genus present in samples}} \times 100$

3. Absolute density of genus/spp x = $\frac{\text{No. of individuals of x in a sample}}{\text{Vol or mass of unit sample}} \times 100$

4. Relative density of spp./genus x = $\frac{\text{No. of individuals of x in a sample}}{\text{Total no. of individuals of all spp/genera in a sample}} \times 100$

5. Prominence value of spp./genus x = Absolute density x √Frequency

6. Biomass = $(a^2 \times b)/(16 \times 10^5)$ micro gram

where *a* is the greatest body width, *b* is the average body length of a nematode in micro millimeters.

7. Importance value = Relative frequency + Relative density + Relative biomass

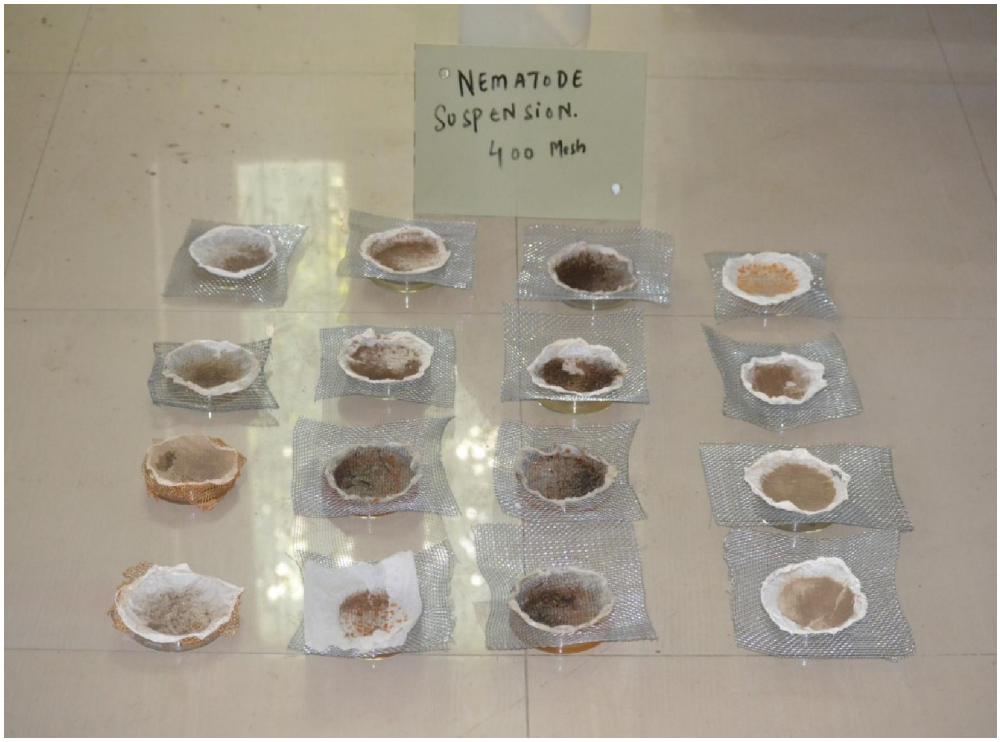


Plate 4: Nematode suspension (Modified Baerman's funnel technique)

Chapter 4

EXPERIMENTAL FINDINGS

Results have been presented under the following headings:

4.1 Identification of pre-dominant plant parasitic nematodes associated with important summer annuals in Mughal Gardens of Srinagar, Kashmir

In all, six nematode species were isolated from the rhizosphere of summer annuals in the Mughal Gardens *viz*., *Helicotylenchus* spp., *Pratylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *Xiphinema insine* and *X. americanum.*

4.1.1 Genus: *Helicotylenchus* Steiner, 1945

Description

Female: Body is vermiform but becomes spiral when heat fixed. Lip region is cup shaped with anterior lip annules. Cephalic framework well developed with cephalids present. Stylet is average sized (22-24µ). Median oesophageal bulb oval to round with average sized valve.Glands overlap the intestines dorsally and ventrally. Excretory pore 121-125 µm from anterior end. Vulva a depressed slit, located at 58.6-64.04 % of the body. Ovaries paired, amphidelphic, outstretched. Tail curved dorsally with or without terminal ventral process.

4.1.2 Genus: *Pratylenchus* Filipjev, 1936

Female: Female body almost straight anteriorly and slightly curved ventrally in posterior half when heat fixed. Cuticular annulation fairly conspicuous. Lip region slightly set off from the body, rounded and bears two annules. Cephalic framework well developed and strongly sclerotized. Spear 18 µm long, with well-developed, broadly rounded basal knobs. Oesophageal lobe overlapping the intestine ventrally. Dorsal esophageal gland orifice about 2 µm behind spear base. Vulva located posteriorly.Ovary single, prodelphic and oocytes are

arranged in single row. Spermatheca broadly oval to nearly round. Tail slightly tapering and terminus rounded.

4.1.3 Genus: *Trichodorus* Cobb, 1913

Female: Thick, almost cylindrical nematode whose body negligibly tapers toward both ends. Body straight when heat fixed. Cuticle smooth, frequently swells in fixed specimens. Lip region rounded with protruding labial papillae. Stylet well developed and 33 per cent of pharynx length. Basal pharyngeal bulb glands slightly overlap the intestine ventrally.The posterior part of the oesophagus ventrally protrudes a little beyond the commencement of the mid-intestine. Female reproductive system didelphic, spermathecae present. Vagina well developed with sclerotised vaginal pieces which are triangular in lateral view.Vaginal length 48-59 per cent of the corresponding body width. Vulva a pore, a transverse slit, or rarely, a longitudinal slit. Tail bluntly/obtusely rounded with anus terminal or sub-terminal.

4.1.4 Genus: *Tylenchorhynchus* Cobb, 1913

Female: Body cylindrical, slightly ventrally arcuate upon fixation.The head has four cuticular annulations and a slight sclerotization. Lip region set off by constriction or continuous with body contour, marked by three annules. Spear 14.23-19.24 µm long, moderately developed, with rounded basal knobs. Oesophageal glands contained in basal bulb, sometimes a lobe of the basal bulb slightly overlapping the intestine. Basal bulb of the oesophagus connected to the intestine by the cardia. Excretory pore located slightly anterior to basal oesophageal bulb. Ovaries two, outstretched. Vulva a transverse slit located at 52-58 per cent of the body. Tail cylindrical or conoid, with terminus usually bluntly rounded.

4.1.5 Genus: *Xiphinema*

Species: *Xiphinema americanum* (Cobb, 1913)

Female: Body ‘C’ shaped upon fixation with tapering ends. Cuticle finely

striated transversely. Lip region rounded, off set from the rest of the body. Stylet 80–90 µ long with 44–50 µ long extensions. Guiding ring is fragile and at 6-8 labial widths from the oral aperture. Cardia simple and conoid. Rectum about one anal body-width long. Intestinal cells packed with coarse, hyaline granules. Ovaries amphidelphic. Vulva a transverse slit, about equatorial. Vagina at right angles to body axis. Tail conoid with a greater curvature dorsally.

4.1.6 Genus: *Xiphinema*

Species: *Xiphinema insigne* (Loos, 1949)

Female: Body significant accurate, anteriorly tapering gradually from base of stylet, then more noticeable from a point four to five lip region widths behind oral opening. Posteriorly, body tapering evenly from anus to tail terminus. Lip region hemispherical set off from rest of body by slight constriction. Styl*et al*most straight, 25 µm long. Flanged portion of stylet 12 µm wide. Vulva non- protruding, vagina transverse. Tail uniformly elongate-conical, about five anal-body-widths in length of 110 µm long.

4.2 Population abundance and distribution of identified plant parasitic nematodes in Mughal Gardens

4.2.1 Status of pre-dominat plant parasitic nematodes associated with summer annuals in Chashma Shahi garden during summer season, 2020

The basic data of 250 cc soil samples collected from ten flowers and the number of nematodes present in those samples is given in table 1. In all, six nematode species were found harbouring the rhizosphere of summer annuals *viz Helicotylenchus* spp., *Pratylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *Xiphinema insine* and *X.americanum*. The data revealed the varying presence of nematode species on each flower, therefore depicting the diverse host ranges of each nematode. Among the ten flowers shown in the table, three flowers *viz*

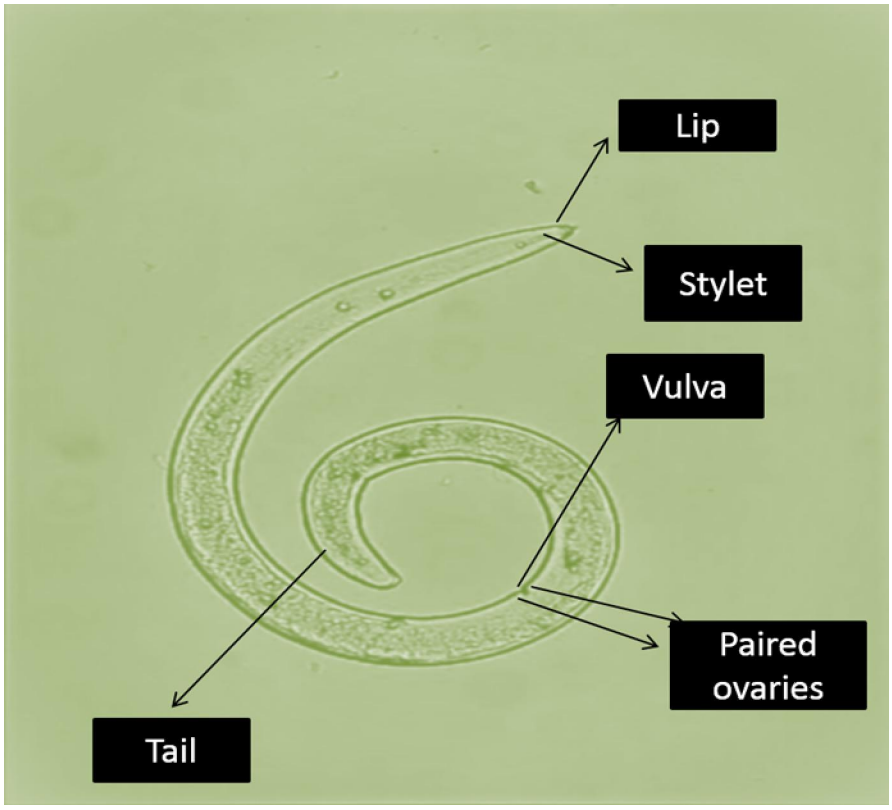


Plate 5: *Helicotylenchus* sp. Steiner, 1945

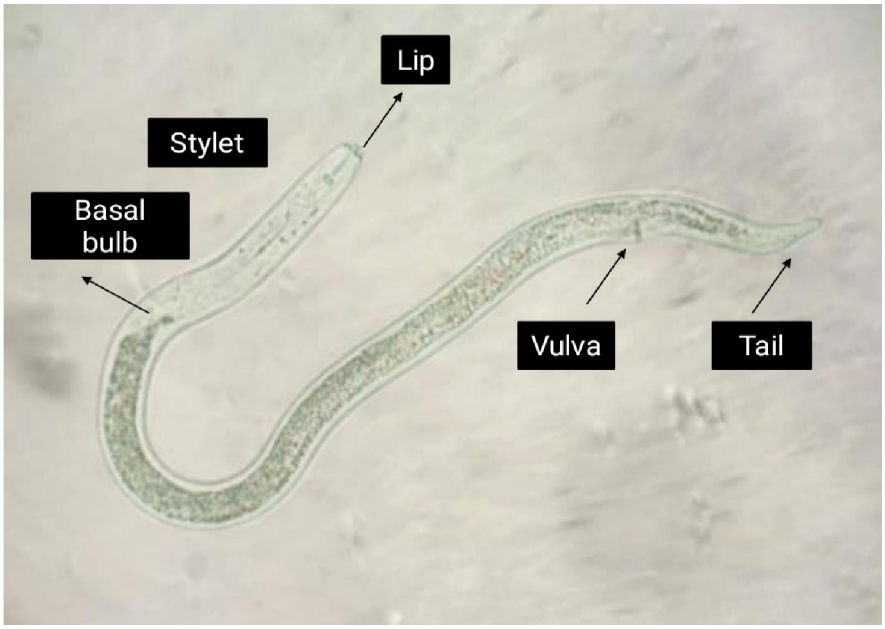


Plate 6: *Pratylenchus* sp. Filipjev, 1936

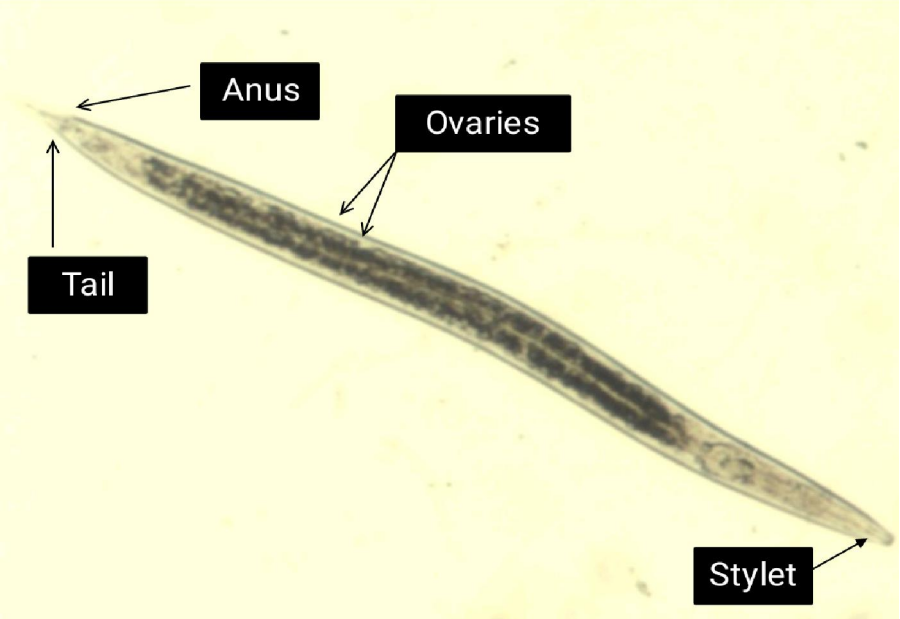


Plate 7: *Trichodorus* Cobb, 1913

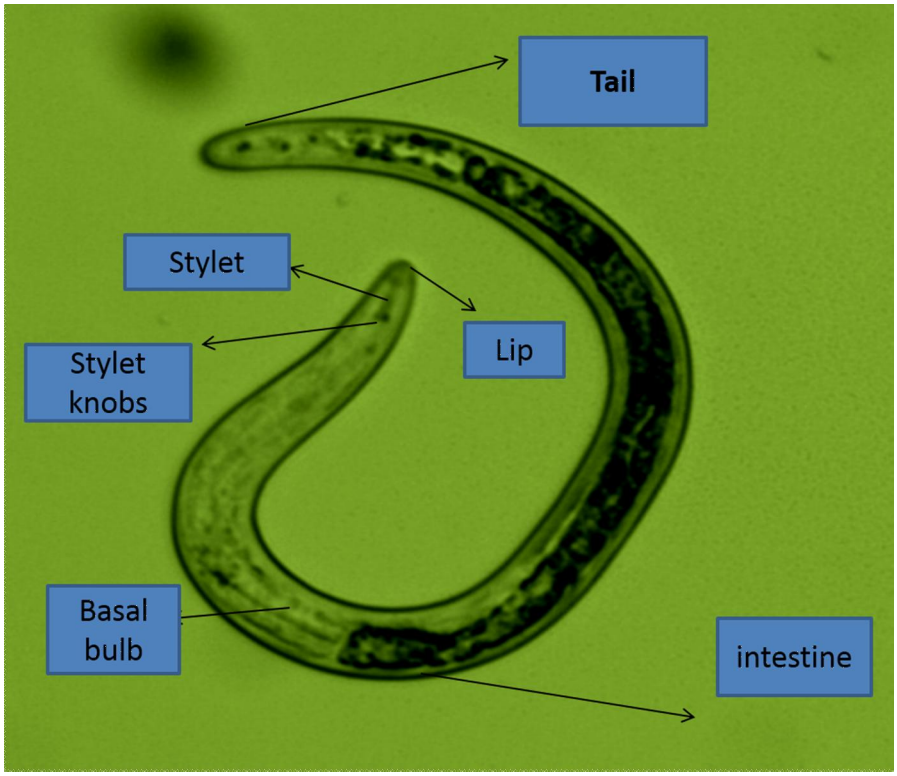


Plate 8: *Tylenchorhynchus* Cobb, 1913

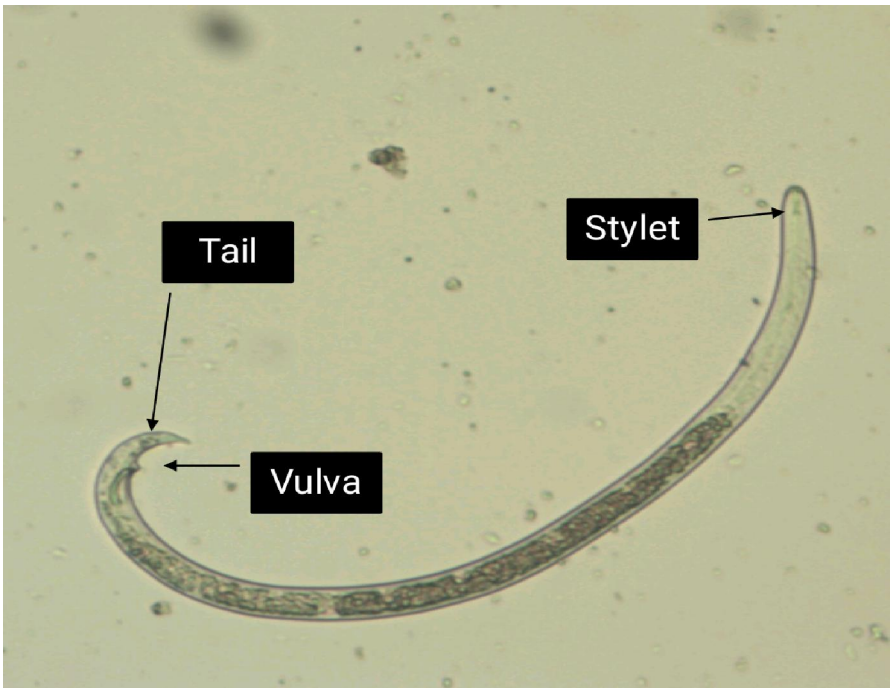


Plate 9: *Xiphinema americanum* (Cobb, 1913)

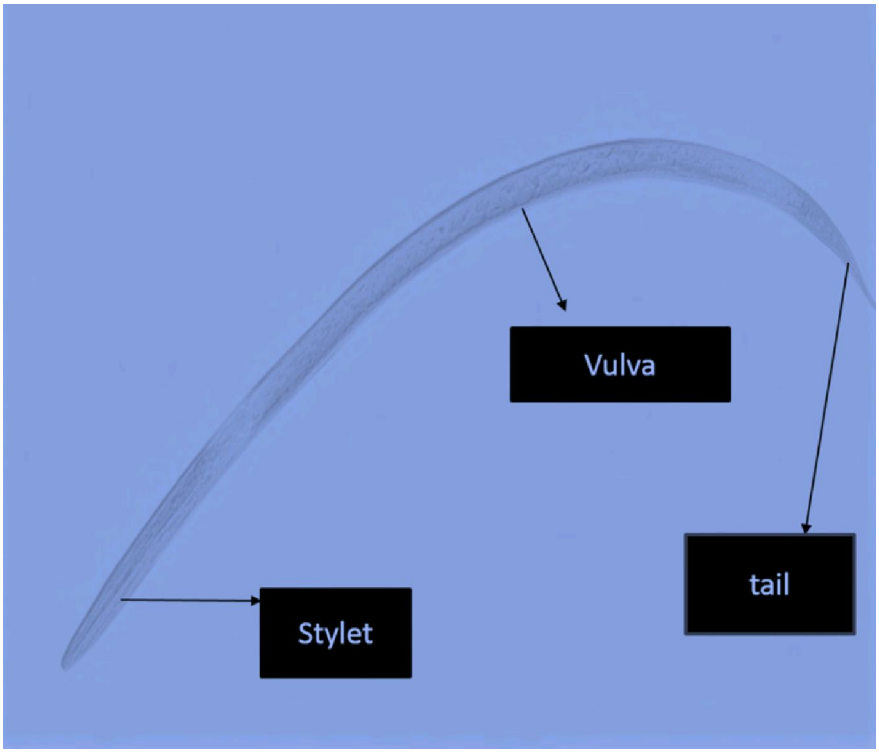


Plate 10: *Xiphinema insigne* loos, 1949

Celosia spp*., Dahlia* spp. *and Tagetes* spp. were found to be harbouring all the six species of nematodes and among the nematodes, *Helicotylenchus* spp. was found on all the ten species of flowers, thereby showing the highest host range among all the six nematode species while the lowest host range was that of *Pratylenchus* spp. showing its presence on only three flowers. The highest populations of *Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *Xiphinema insine*, *X.americanum* and *Pratylenchus* spp. as revealed by table 1 were 345 (in 250 cc soil samples) on *Dahlia* spp., 316 (in 250cc soil samples) on *Petunia* spp., 238 (in 250cc soil samples) on *Dahlia* spp., 122 (in 250cc soil samples) on *Zinnia* spp., 250 (in 250cc soil samples) on *Gomphrena* spp. and 74 (in 250cc soil samples) on *Dahlia* spp. respectively.

After the species-wise analysis, the community structure of plant parasitic nematodes on summer annuals is presented in table 1a. The data presents the absolute density, relative density, absolute frequency, relative frequency and prominence value of plant parasitic nematodes on summer annuals which is discussed below.

***Aster* spp.:** The data revealed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 74.00 with 100 per cent frequency. The per cent relative density of this species was recorded as 47.66 in comparison to other species with prominence value of 740. The absolute density of *Tylenchorhynchus* spp. was computed to be 31.6 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 20.35 in comparison to other species with prominence value of 316. *Trichodorus* spp. had the absolute density of 24.00 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 15.5 in comparison to other species with prominence value of 195.84.The status of *X.americanum* with respect to absolute density was

recorded as 25.66 with frequency of 100 percent. Its percent relative density was recorded as 16.5 in comparison to other species with prominence value of 256.6.

***Amaranthus* spp.:** The data revealed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *X. insigne* and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 35.00 with 100 percent frequency. The per cent relative density of this species was recorded as 30.6 in comparison to other species with prominence value of 350. The absolute density of *Tylenchorhynchus* spp. was computed to be 47.00 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 41.11 in comparison to other species with prominence value of 470. *X.insigne* had the absolute density of 14.66 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 12.8 in comparison to other species with prominence value of 119.6.The status of *X.americanum* with respect to absolute density was recorded as 17.66 with frequency of 100 percent. Its percent relative density was recorded as 15.4 in comparison to other species with prominence value of 176.6.

***Celosia* spp.:** The data revealed the association of all the six nematodes. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 73.3 with 66.66 percent frequency. The per cent relative density of this species was recorded as 37.2 in comparison to other species with prominence value of 432.48. The absolute density of *Tylenchorhynchus* spp. was computed to be 51.33 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 26.1 in comparison to other species with prominence value of 513.3. *Trichodorus* spp. had the absolute density of 30.33 with percent frequency of about 100. The per cent relative density of this species was recorded as 17.1 in comparison to other species with prominence value of 303.3. The status of *X.insigne* with respect to absolute density was recorded as 24.66 with frequency of 33.33 percent. Its percent relative density was recorded as 13.9 in comparison to other species with prominence value of 201.2. Similarly, the absolute

population densities of *X.americanum* and *Pratylenchus* spp. was recorded to be 10.00 and 8.00 with percent frequency of about 66.66 and 33.33 respectively. Their percent relative densities were recorded as 5.6 and 4.5 with prominence values of 81.6 and 46.16 respectively.

***Dahlia* spp.:** Dahlia showed the infestation of all the six nematodes. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 115.00 with 100 percent frequency. The per cent relative density of this species was recorded as 31.07 in comparison to other species with prominence value of 1150. The absolute density of *Tylenchorhynchus* spp. was computed to be 91.3 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 24.66 in comparison to other species with prominence value of 913.*Trichodorus* spp. had the absolute density of 79.33 with percent frequency of about 100. The per cent relative density of this species was recorded as 21.4 in comparison to other species with prominence value of 793. The status of *X.insigne* with respect to absolute density was recorded as 35.6 with frequency of 66.66 percent. Its percent relative density was recorded as 9.6 in comparison to other species with prominence value of 290.4. Similarly, the absolute population densities of *X.americanum* and *Pratylenchus* spp. was recorded to be 24.6 and 24.3 with percent frequency of about 100 and 66.66 respectively. Their percent relative densities were recorded as 6.66 and 6.56 with prominence values of 246 and 198.2 respectively.

***Gomphrena* spp.:** The data revealed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *X. insigne* and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 41 with 66.66 percent frequency. The per cent relative density of this species was recorded as 26.22 in comparison to other species with prominence value of 334.5. The absolute density of *Tylenchorhynchus* spp. was computed to be 19.33 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 12.36 in comparison to other species with

prominence value of 193.3. *X.insigne* had the absolute density of 12.66 with percent frequency of about 33.33. The per cent relative density of this species was recorded as 8.09 in comparison to other species with prominence value of 73.04.The status of *X.americanum* with respect to absolute density was recorded to be highest as 83.33 with frequency of 100 percent. Its percent relative density was recorded as 53.3 in comparison to other species with prominence value of 833.3.

***Impatiens* spp.:** Out of six nematode species, four nematode species were found to be infecting this summer annual *viz Helicotylenchus* spp., *Trichodorus* spp., *X. insigne* and *X.americanum.* The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 63.3 with 100 percent frequency. The per cent relative density of this species was recorded as 40.4 in comparison to other species with prominence value of 633.The absolute density of *Trichodorus* spp. was computed to be 41.6 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 26.5 in comparison to other species with prominence value of 416. *X.insigne* had the absolute density of 19.3 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 12.3 in comparison to other species with prominence value of 157.5.The status of *X.americanum* with respect to absolute density was recorded to be as 32.3 with frequency of 66.66 percent. Its percent relative density was recorded as 20.6 in comparison to other species with prominence value of 263.5.

***Petunia* spp.:** This summer annual also harboured four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.insigne.* The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 83.3 with 100 percent frequency. The per cent relative density of this species was recorded as 31.14 in comparison to other species with prominence value of 833. The absolute density of *Tylenchorhynchus* spp. was computed to be 105.3 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 39.3 in comparison to other species with prominence

value of 1053. *Trichodorus* spp. had the absolute density of 35.3 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 13.2 in comparison to other species with prominence value of 288.04.The status of *X.insigne* with respect to absolute density was recorded as 43.6 with frequency of 100 percent. Its percent relative density was recorded as 16.3 in comparison to other species with prominence value of 436.

***Salvia* spp.:** The data showed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 74.6 with 100 percent frequency. The per cent relative density of this species was recorded as 34.5 in comparison to other species with prominence value of 746. The absolute density of *Tylenchorhynchus* spp. was computed to be 60.0 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 27.7 in comparison to other species with prominence value of 600. *Trichodorus* spp. had the absolute density of 54.00 with percent frequency of about 100. The per cent relative density of this species was recorded as 24.9 in comparison to other species with prominence value of 540.The status of *X.americanum* with respect to absolute density was recorded as 27.6 with frequency of 66.66 percent. Its percent relative density was recorded as 12.7 in comparison to other species with prominence value of 225.2.

***Tagetes* spp.:** This summer annual also showed the infestation of all the six nematodes. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 27.00 with 100 percent frequency. The per cent relative density of this species was recorded as 13.5 in comparison to other species with prominence value of 270. The absolute density of *Tylenchorhynchus* spp. was computed to be 40.00 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 27.9 in comparison to other species with prominence value of 400.*Trichodorus* spp. had the absolute density of 6.66 with percent frequency of about 33.33. The per cent relative density of this species was

recorded as 4.65 in comparison to other species with prominence value of 38.4. The status of *X.insigne* with respect to absolute density was recorded as 12.6 with frequency of 66.66 percent. Its percent relative density was recorded as 8.85 in comparison to other species with prominence value of 103.3. Similarly, the absolute population densities of *X.americanum* and *Pratylenchus* spp. was recorded to be 37.33 and 19.6 with percent frequency of about 100 and 66.66 respectively. Their percent relative densities were recorded as 26.11 and 18.88 with prominence values of 373.3 and 159.9 respectively.

***Zinnia* spp.:** Four nematode species were found to be infecting this summer annual *viz Helicotylenchus* spp., *Trichodorus* spp., *X. insigne* and *X.americanum.* The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 63.66 with 66.66 percent frequency. The per cent relative density of this species was recorded as 32.3 in comparison to other species with prominence value of 519.5.The absolute density of *Trichodorus* spp. was computed to be 78.00 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 39.6 in comparison to other species with prominence value of 780. *X.insigne* had the absolute density of 40.66 with percent frequency of about 100. The per cent relative density of this species was recorded as 7.44 in comparison to other species with prominence value of 406.6.The status of *X.americanum* with respect to absolute density was recorded to be as 14.66 with frequency of 33.33 percent. Its percent relative density was recorded as 20.6 in comparison to other species with prominence value of 263.5.

4.2.1.1 Relative infestation of summer annuals to pre-dominant plant parasitic nematodes in Chashma Shahi garden during summer season, 2020

After comparison of thirty soil samples of Chashma Shahi garden collected from all ten flowers, the population density of pre-dominant plant parasitic nematodes are presented in descending order in Table 1b. This table shows a comparison in the occurance of each plant parasitic nematode on different summer

annuals along with their absolute densities. Among all the ten flowers, *Helicotylenchus* spp. had the highest population density on *Dahlia* spp. (115 per 250 cc soil) followed by *Petunia* spp. (83.3 per 250cc soil) and the lowest population density on *Tagetes* spp. (27 per 250 cc soil). *Tylenchorynchus* spp. showed the maximum population density on *Petunia* spp. (105.3 per 250 cc soil) and the lowest density on *Gomphrena* spp. (19.33 per 250 cc soil). *Trichodorus* spp. had the highest population density on *Zinnia* spp. (78 per 250 cc soil) and the lowest density on *Tagetes* spp. (6.66 per 250 cc soil). Similarly, *X. insigne* and *X. americanum* showed the maximum population densities on *Petunia* spp. (43.6 per 250 cc soil) and *Gomphrena* spp. (83.33 per 250 cc soil) respectively. *Pratylenchus* spp. was found on only three flowers with its maximum population density on *Dahlia* spp. (24.3 per 250 cc soil).

Table 1: Pre-dominant plant parasitic nematodes (in 250 cc soil samples) associated with summer annuals in Chashma Shahi garden during summer season, 2020

	No. of nematode species in 250cc soil samples					
Flowers	***Helicotylenchus* spp.**	***Tylenchorynchus* spp.**	***Trichodorus* spp.**	***X.insigne***	***X.americanum***	***Pratylenchus* spp.**
Aster spp.	222	95	78	-	77	-
Amaranthus spp.	105	141	-	44	53	-
Celosia spp.	220	154	91	73	15	24
Dahlia spp.	345	274	238	107	128	74
Gomphrena spp.	123	58	-	38	250	-
Impatiens spp.	97	-	62	43	39	-
Petunia spp.	250	316	106	131	-	-
Salvia spp.	224	180	162	-	83	-
Tagetes spp.	81	120	20	38	112	58
Zinnia spp.	201	-	234	122	44	-
Total	**1868**	**1338**	**991**	**596**	**801**	**156**

Table 1a: Community analysis of pre-dominant plant parasitic nematodes associated with summer annuals in Chashma Shahi garden during summer season, 2020

Flowers	Nematode species	AD	RD (%)	AF (%)	RF (%)	PV
Aster spp.	*Helicotylenchus* spp.	**74**	47.66	100	27.3	740
	Tylenchorynchus spp.	31.6	20.35	100	27.3	316
	Trichodorus spp.	24	15.5	66.66	18.2	195.84
	X.americanum	25.66	16.5	100	27.3	256.6
Amaranthus spp.	*Helicotylenchus* spp.	35	30.6	100	27.3	350
	Tylenchorynchus spp.	**47**	41.11	100	27.3	470
	X.insigne	14.66	12.8	66.66	18.2	119.6
	X.americanum	17.66	15.4	100	27.3	176.6
Celosia spp.	*Helicotylenchus* spp.	**73.3**	37.2	66.66	16.66	432.48
	Tylenchorynchus spp.	51.33	28.9	100	25	513.3
	Trichodorus spp.	30.33	17.10	100	25	303.3
	X.insigne	24.66	13.9	33.33	8.33	201.2
	X.americanum	10	5.6	66.66	16.66	81.6
	Pratylenchus spp.	8	4.5	33.33	8.33	46.16
Dahlia spp.	*Helicotylenchus* spp.	**115**	31.07	100	18.75	1150
	Tylenchorynchus spp.	91.3	24.66	100	18.75	913
	Trichodorus spp.	79.3	21.4	100	18.75	793
	X.insigne	35.6	9.6	66.66	12.5	290.4
	X.americanum	24.6	6.66	100	18.75	246
	Pratylenchus spp.	24.3	6.56	66.66	12.5	198.2
Gomphrena spp.	*Helicotylenchus* spp.	41	26.22	66.66	22.22	334.5
	Tylenchorynchus spp.	19.33	12.36	100	33.33	193.3
	X.insigne	12.66	8.09	33.33	11.11	73.04
	X.americanum	**83.33**	53.3	100	33.33	833.3

Contd….

Table 1a: contd….

Impatiens spp.	*Helicotylenchus* spp.	**63.3**	40.4	100	30	633
	Trichodorus spp.	41.6	26.5	100	30	416
	X. insigne	19.3	12.3	66.66	19.9	157
	X. americanum	32.33	20.6	66.66	19.9	263.5
Petunia spp.	*Helicotylenchus* spp.	83.3	31.14	100	27.3	833
	Tylenchorynchus spp.	**105.3**	39.3	100	27.3	1053
	Trichodorus spp.	35.3	13.2	66.66	18.2	288.04
	X.insigne	43.6	16.3	100	27.3	436
Salvia spp.	*Helicotylenchus* spp.	**74.6**	34.5	100	27.3	746
	Tylenchorynchus spp.	60	27.7	100	27.3	600
	Trichodorus spp.	54	24.9	100	27.3	540
	X.americanum	27.6	12.7	66.66	18.2	225.2
Tagetes spp.	*Helicotylenchus* spp.	27	13.5	100	21.4	270
	Tylenchorynchus spp.	**40**	27.9	100	21.4	400
	Trichodorus spp.	6.66	4.65	33.33	7.14	38.4
	X.insigne	12.66	8.85	66.66	14.3	103.3
	X.americanum	37.33	26.11	100	21.4	373.3
	Pratylenchus spp.	19.6	18.88	66.66	14.3	159.9
Zinnia spp.	*Helicotylenchus* spp.	63.66	32.3	66.66	22.22	519.5
	Trichodorus spp.	**78**	39.6	100	33.33	780
	X. insigne	40.66	7.44	100	33.33	406.6
	X. americanum	14.66	20.6	33.33	11.11	84.6

AD=Absolute density, RD=Relative density, AF=Absolute frequency, RF=Relative frequency, PV=Prominence value

Table 1b: Relative infestation of summer annuals to pre-dominant plant parasitic nematodes in Chashma Shahi garden during summer season, 2020

Flower	Order of Absolute Density (AD) of nematode species in descending order					
Aster spp.	*Helicotylenchus* spp. (74.00)	*Tylenchorynchus* spp. (31.6)	X.americanum (25.66)	*Trichodorus* spp. (24)		
Amaranthus spp.	*Tylenchorynchus* spp. (47.00)	*Helicotylenchus* spp. (35)	*X.americanum* (17.66)	*X.insigne* (14.66)		
Celosia spp.	*Helicotylenchus* spp. (73.3)	*Tylenchorynchus* spp. (51.33)	*Trichodorus* spp. (30.33)	*X.insigne* (24.66)	*X.americanum* (10.00)	*Pratylenchus* spp. (8.00)
Dahlia spp.	*Helicotylenchus* spp. (115.00)	*Tylenchorynchus* spp. (91.3)	*Trichodorus* spp. (79.33)	*X.insigne* (35.6)	*X.americanum* (24.6)	*Pratylenchus* spp. (24.3)
Gomphrena spp.	*X.americanum* (83.33)	*Helicotylenchus* spp. (41.00)	*Tylenchorynchus* spp. (19.33)	*X.insigne* (12.66)		

Contd….

Table 1b: contd…

Impatiens spp.	*Helicotylenchus* spp. (63.33)	*Trichodorus* spp. (31.33)	*X.insigne* (14.3)	*X.americanum* (13)		
Petunia spp.	*Tylenchorynchus* spp. (105.3)	*Helicotylenchus* spp. (83.3)	*X.insigne* (43.6)	*Trichodorus* spp. (35.3)		
Salvia spp.	*Helicotylenchus* spp. (74.6)	*Tylenchorynchus* spp. (60.0)	*Trichodorus* spp. (54.0)	*X.americanum* (27.6)		
Tagetes spp.	*Tylenchorynchus* spp. (40.00)	*X.americanum* (37.33)	*Helicotylenchus* spp. (27.00)	*Pratylenchus* spp. (19.3)	*X.insigne* (12.6)	*Trichodorus* spp. (6.66)
Zinnia spp.	*Trichodorus* spp. (78)	*Helicotylenchus* spp. (63.66)	*X.insigne* (40.6)	*X.americanum* (14.6)		

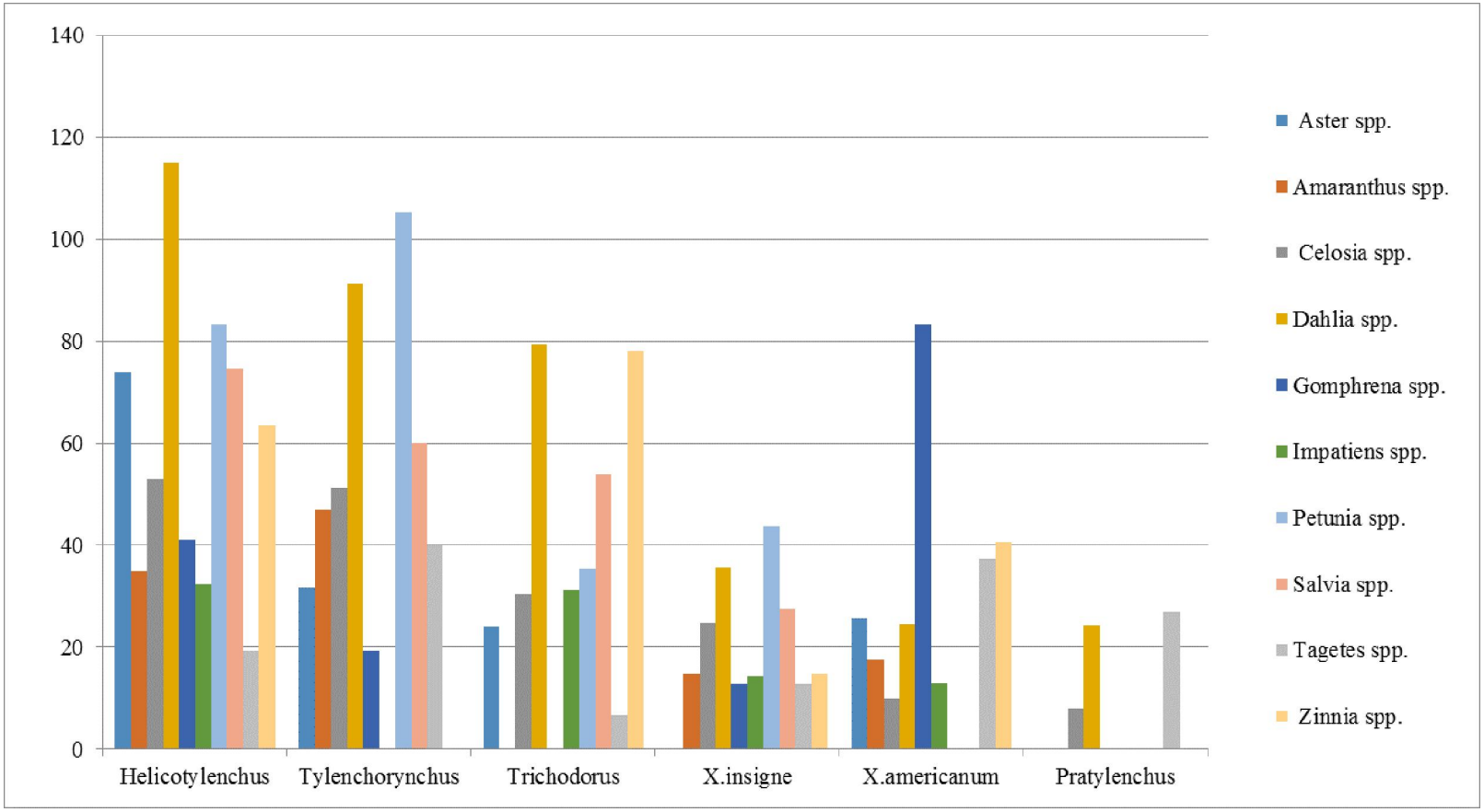


Fig. 1: Population density (per 250 cc soil) of pre-dominant plant parasitic nematodes on summer annuals in Chashma Shahi.

4.2.2 Status of pre-dominat plant parasitic nematodes associated with summer annuals in Nishat garden during summer season, 2020.

The basic data of 250 cc soil samples collected from ten flowers and the number of nematodes present in those samples is given in table 2. In all, six nematode species were found harbouring the rhizosphere of summer annuals *viz Helicotylenchus* spp., *Pratylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *Xiphinema insine* and *X.americanum*. The data of this garden varied a little with that of Nishat in terms of the number of nematode species hosted by each flower.Among the ten flowers shown in the table, two flowers *viz Celosia* spp. *and Tagetes* spp. were found to be harbouring all the six species of nematodes unlike Chashma Shahi and among the nematodes, *Helicotylenchus* spp. was found on all the ten species of flowers, thereby showing the highest host range among all the six nematode species while the lowest host range was that of *Pratylenchus* spp. showing its presence on only three flowers. The highest populations of *Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *Xiphinema insine*, *X.americanum* and *Pratylenchus* spp. as revealed by table 2 were 305 (in 250 cc soil samples) on *Salvia* spp., 285 (in 250cc soil samples) on *Petunia* spp., 285 (in 250cc soil samples) on *Salvia* spp., 160 (in 250cc soil samples) on *Zinnia* spp., 280 (in 250cc soil samples) on *Gomphrena* spp. and 84 (in 250cc soil samples) on *Dahlia* spp. respectively.

After the species-wise analysis, the community structure of plant parasitic nematodes on summer annuals is presented in table 2a. The data presents the absolute density, relative density, absolute frequency, relative frequency and prominence value of plant parasitic nematodes on summer annuals which is discussed below.

***Aster* spp.:** The data revealed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 37.33 with 66.66 percent frequency. The per cent relative density of

this species was recorded as 34.1 in comparison to other species with prominence value of 304.6. The absolute density of *Tylenchorhynchus* spp. was computed to be 26.6 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 24.3 in comparison to other species with prominence value of 266. *Trichodorus* spp. had the absolute density of 20.6 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 18.8 in comparison to other species with prominence value of 168.1.The status of *X.americanum* with respect to absolute density was recorded as 25 with frequency of 100 percent. Its percent relative density was recorded as 22.8 in comparison to other species with prominence value of 250.

***Amaranthus* spp.:** The data revealed the association of three nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 40.00 with 100 percent frequency. The per cent relative density of this species was recorded as 37.9 in comparison to other species with prominence value of 400. The absolute density of *Tylenchorhynchus* spp. was computed to be 50.00 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 47.11 in comparison to other species with prominence value of 500. The status of *X.americanum* with respect to absolute density was recorded as 16.3 with frequency of 66.66 percent. Its percent relative density was recorded as 13.8 in comparison to other species with prominence value of 133.01.

***Celosia* spp.:** The data revealed the association of all the six nematodes. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 58.3 with 100 percent frequency. The per cent relative density of this species was recorded as 29.2 in comparison to other species with prominence value of 583. The absolute density of *Tylenchorhynchus* spp. was computed to be 46.00 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 23.05 in comparison to other species with prominence value of 460. *Trichodorus* spp. had the absolute density of 36.00 with percent frequency of

about 66.66. The percent relative density of this species was recorded as 18.04 in comparison to other species with prominence value of 293.7. The status of *X.insigne* with respect to absolute density was recorded as 26.6 with frequency of 66.66 percent. Its percent relative density was recorded as 13.3 in comparison to other species with prominence value of 217.1. Similarly, the absolute population densities of *X.americanum* and *Pratylenchus* spp. was recorded to be 21.6 and 11.00 with percent frequency of about 66.66 and 33.33 respectively. Their percent relative densities were recorded as 10.8 and 5.5 with prominence values of 176.3 and 63.47 respectively.

***Dahlia* spp.:** Dahlia showed the infestation of five nematodes *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *X.americanum* and *Pratylenchus* spp. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 72.6 with 100 percent frequency. The per cent relative density of this species was recorded as 26.3 in comparison to other species with prominence value of 726. The absolute density of *Tylenchorhynchus* spp. was computed to be 68.00 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 24.6 in comparison to other species with prominence value of 680.*Trichodorus* spp. had the absolute density of 41.6 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 15.1 in comparison to other species with prominence value of 339.5. Similarly, the absolute population densities of *X.americanum* and *Pratylenchus* spp. was recorded to be 35.00 and 28.00 with percent frequency of about 100 and 100 respectively. Their percent relative densities were recorded as 12.7 and 10.2 with prominence values of 350 and 280 respectively.

***Gomphrena* spp.:** The data revealed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *X. insigne* and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 68.3 with 100 percent frequency. The per cent relative density of this species was recorded as 33.5 in comparison to other species with prominence

value of 683. The absolute density of *Tylenchorhynchus* spp. was computed to be 25.00 with 66.66 percent frequency of occurance. The per cent relative density of this species was recorded as 12.26 in comparison to other species with prominence value of 204. *X.insigne* had the absolute density of 17.3 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 8.5 in comparison to other species with prominence value of 141.2.The status of *X.americanum* with respect to absolute density was recorded to be highest as 93.3 with frequency of 100 percent. Its percent relative density was recorded as 45.8 in comparison to other species with prominence value of 933.

***Impatiens* spp.:** Out of six nematode species, four nematode species were found to be infecting this summer annual *viz Helicotylenchus* spp., *Trichodorus* spp., *X. insigne* and *X.americanum.*

The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 45.00 with 100 percent frequency. The per cent relative density of this species was recorded as 44.5 in comparison to other species with prominence value of 450.The absolute density of *Trichodorus* spp. was computed to be 22.6 with 66.66 percent frequency of occurance. The per cent relative density of this species was recorded as 22.13 in comparison to other species with prominence value of 184.3. *X.insigne* had the absolute density of 12.6 with percent frequency of about 33.33. The per cent relative density of this species was recorded as 12.4 in comparison to other species with prominence value of 72.6.The status of *X.americanum* with respect to absolute density was recorded to be as 20.6 with frequency of 66.66 percent. Its percent relative density was recorded as 20.3 in comparison to other species with prominence value of 168.1.

***Petunia* spp.:** This summer annual also harboured four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.insigne.* The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 66.6 with 100 percent frequency. The per cent relative density of this

species was recorded as 27.5 in comparison to other species with prominence value of 666.6. The absolute density of *Tylenchorhynchus* spp. was computed to be 95.00 with 66.66 percent frequency of occurance. The per cent relative density of this species was recorded as 39.2 in comparison to other species with prominence value of 775.2. *Trichodorus* spp. had the absolute density of 31.3 with percent frequency of about 100. The per cent relative density of this species was recorded as 12.9 in comparison to other species with prominence value of 313.3.The status of *X.insigne* with respect to absolute density was recorded as 49.3 with frequency of 66.66 percent. Its percent relative density was recorded as 20.3 in comparison to other species with prominence value of 402.3.

***Salvia* spp.:** The data showed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 101.6 with 100 percent frequency. The per cent relative density of this species was recorded as 32.7 in comparison to other species with prominence value of 1016. The absolute density of *Tylenchorhynchus* spp. was computed to be 66.6 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 23.1 in comparison to other species with prominence value of 666. *Trichodorus* spp. had the absolute density of 71.6 with percent frequency of about 100. The per cent relative density of this species was recorded as 30.6 in comparison to other species with prominence value of 716.The status of *X.americanum* with respect to absolute density was recorded as 42.00 with frequency of 100 percent. Its percent relative density was recorded as 13.5 in comparison to other species with prominence value of 420.

***Tagetes* spp.:** This summer annual also showed the infestation of all the six nematodes. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 39.00 with 66.66 percent frequency. The per cent relative density of this species was recorded as 23.8 in comparison to other species with prominence value of 318.2. The absolute density of *Tylenchorhynchus* spp. was computed to

be 44.6 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 27.3 in comparison to other species with prominence value of 446.*Trichodorus* spp. had the absolute density of 15.00 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 9.2 in comparison to other species with prominence value of 122.4. The status of *X.insigne* with respect to absolute density was recorded as 8.6 with frequency of 33.33 percent. Its percent relative density was recorded as 5.3 in comparison to other species with prominence value of 49.6. Similarly, the absolute population densities of *X.americanum* and *Pratylenchus* spp. was recorded to be 42.3 and 14.00 with percent frequency of about 100 and 33.33 respectively. Their percent relative densities were recorded as 25.8 and 8.7 with prominence values of 423 and 80.7 respectively

***Zinnia* spp.:** Four nematode species were found to be infecting this summer annual *viz Helicotylenchus* spp., *Trichodorus* spp., *X. insigne* and *X.americanum.* The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 65.00 with 100 percent frequency. The per cent relative density of this species was recorded as 31.1 in comparison to other species with prominence value of 650.The absolute density of *Trichodorus* spp. was computed to be 72.6 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 34.7 in comparison to other species with prominence value of 726. *X.insigne* had the absolute density of 53.3 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 25.5 in comparison to other species with prominence value of 726.The status of *X.americanum* with respect to absolute density was recorded to be as 18.3 with frequency of 33.33 percent. Its percent relative density was recorded as 8.7 in comparison to other species with prominence value of 105.6.

4.2.2.1 Relative infestation of summer annuals to pre-dominant plant parasitic nematodes in Nishat garden during summer season, 2020.

After comparison of thirty soil samples of Nishat garden collected from all ten flowers, the population density of pre-dominant plant parasitic nematodes are presented in descending order in Table 2b. This table shows a comparison in the occurance of each plant parasitic nematode on different summer annuals along with their absolute densities. Among all the ten flowers, *Helicotylenchus* spp. had the highest population density on *Salvia* spp. (101.6 per 250 cc soil) and the lowest population density on *Aster* spp. (37.33 per 250 cc soil). *Tylenchorynchus* spp. showed the maximum population density on *Petunia* spp. (95 per 250 cc soil) and the lowest density on *Gomphrena* spp. (25 per 250 cc soil). *Trichodorus* spp. had the highest population density on *Zinnia* spp. (72.6 per 250 cc soil) and the lowest density on *Tagetes* spp. (15 per 250 cc soil). Similarly, *X. insigne* and *X. americanum* showed the maximum population densities on *Zinnia* spp. (58.3 per 250 cc soil) and *Gomphrena* spp. (93.3 per 250 cc soil) respectively. *Pratylenchus* spp. was found on only three flowers with its maximum population density on *Dahlia* spp. (28.2 per 250 cc soil).

Table 2: Pre-dominant plant parasitic nematodes (in 250 cc soil samples) associated with summer annuals in Nishat garden during summer season, 2020

Flowers	No. of nematode species in 250cc soil samples					
	***Helicotylenchus* spp.**	***Tylenchorynchus* spp.**	***Trichodorus* spp.**	***X.insigne***	***X.americanum***	***Pratylenchus* spp.**
Aster spp.	112	80	62	-	75	-
Amaranthus spp.	120	150	-	-	49	-
Celosia spp.	175	138	108	80	65	33
Dahlia spp.	218	204	125	-	105	84
Gomphrena spp.	205	75	-	52	280	-
Impatiens spp.	135	-	68	38	62	-
Petunia spp.	285	285	94	148	-	-
Salvia spp.	200	215	285	-	126	-
Tagetes spp.	117	134	45	26	127	42
Zinnia spp.	195	-	218	160	55	-
Total	**1762**	**1281**	**1005**	**504**	**944**	**159**

Table 2a: Community analysis of pre-dominant plant parasitic nematodes associated with summer annuals in Nishat garden during summer season, 2020

Flowers	Nematode species	AD	RD (%)	AF (%)	RF (%)	PV
Aster spp.	*Helicotylenchus* spp.	**37.33**	34.1	66.66	19.9	304.6
	Tylenchorynchus spp.	26.6	24.3	100	30	266
	Trichodorus spp.	20.6	18.8	66.66	19.9	168.1
	X.americanum	25	22.8	100	30	250
Amaranthus spp.	*Helicotylenchus* spp.	40	37.9	100	37.5	400
	Tylenchorynchus spp.	**50**	47.1	100	37.5	500
	X.americanum	16.3	13.8	66.66	24.9	133.01
Celosia spp.	*Helicotylenchus* spp.	**58.3**	29.2	100	23.07	583
	Tylenchorynchus spp.	46	23.05	100	23.07	460
	Trichodorus spp.	36	18.04	66.66	15.38	293.7
	X.insigne	26.6	13.3	66.66	15.38	217.1
	X.americanum	21.6	10.8	66.66	15.38	176.3
	Pratylenchus spp.	11	5.5	33.33	7.7	63.47
Dahlia spp.	*Helicotylenchus* spp.	**72.6**	26.3	100	18.75	726
	Tylenchorynchus spp.	68	24.6	100	18.75	680
	Trichodorus spp.	41.6	15.1	66.66	12.5	339.5
	X.americanum	35	12.7	100	18.75	350
	Pratylenchus spp.	28	10.2	100	18.75	280
Gomphrena spp.	*Helicotylenchus* spp.	68.3	33.5	100	30	683
	Tylenchorynchus spp.	25	12.26	66.66	19.9	204
	X.insigne	17.3	8.5	66.66	19.9	141.2
	X.americanum	**93.3**	45.8	100	30	933

Contd….

Table 2a: contd….

Impatiens spp.	*Helicotylenchus* spp.	**45**	44.5	100	37.5	450
	Trichodorus spp.	22.6	22.13	66.66	24.9	184.3
	X. insigne	12.6	12.4	33.33	12.5	72.6
	X. americanum	20.6	20.3	66.66	24.9	168.1
Petunia spp.	*Helicotylenchus* spp.	66.6	27.5	100	30	666.6
	Tylenchorynchus spp.	**95**	39.2	66.66	19.9	775.2
	Trichodorus spp.	31.33	12.9	100	30	313.3
	X.insigne	49.33	20.3	66.66	19.9	402.3
Salvia spp.	*Helicotylenchus* spp.	**101.6**	32.7	100	25	1016
	Tylenchorynchus spp.	66.6	23.1	100	25	666
	Trichodorus spp.	71.6	30.6	100	25	716
	X.americanum	42	13.5	100	25	420
Tagetes spp.	*Helicotylenchus* spp.	39	23.8	66.66	16.6	318.2
	Tylenchorynchus spp.	**44.6**	27.3	100	25	446
	Trichodorus spp.	15	9.2	66.66	16.6	122.4
	X.insigne	8.6	5.3	33.33	8.3	49.6
	X.americanum	42.3	25.8	100	25	423
	Pratylenchus spp.	14	8.6	33.33	8.3	80.7
Zinnia spp.	*Helicotylenchus* spp.	65	31.1	100	33.33	650
	Trichodorus spp.	**72.6**	34.7	100	33.33	726
	X. insigne	53.3	25.5	66.66	22.22	434.9
	X. americanum	18.3	8.7	33.33	11.11	105.6

AD=Absolute density, RD=Relative density, AF=Absolute frequency, RF=Relative frequency, PV=Prominence value

Table 2b: Relative infestation of species of summer annuals to pre-dominant plant parasitic nematodes in Nishat garden during summer season, 2020

Flower	Order of prevalence (AD) of nematodes in descending order					
Aster spp.	*Helicotylenchus* spp. (37.33)	*Tylenchorynchus* spp. (26.6)	*X.americanum* spp. (25)	*Trichodorus* spp. (20.6)		
Amaranthus spp.	*Tylenchorynchus* spp. (50.0)	*Helicotylenchus* spp. (40.00)	*X.americanum* (16.33)			
Celosia spp.	*Helicotylenchus* spp. (58.3)	*Tylenchorynchus* spp. (46.00)	*Trichodorus* spp. (36.1)	*X.insigne* (26.66)	*X.americanum* (21.6)	*Pratylenchus* spp. (11.2)
Dahlia spp.	*Helicotylenchus* spp. (72.6)	*Tylenchorynchus* spp. (68.1)	*Trichodorus* spp. (41.6)	*X.americanum* (35)	*Pratylenchus* spp. (28.2)	

Contd…

Table 2b contd….

Gomphrena spp.	*X.americanum* (93.3)	*Helicotylenchus* spp. (68.3)	*Tylenchorynchus* spp. (25)	*X.insigne* (17.3)		
Impatiens spp.	*Helicotylenchus* spp. (45.3)	*Trichodorus* spp. (22.6)	*X.americanum* (20.6)	*X.insigne* (12.6)		
Petunia spp.	*Tylenchorynchus* spp. (95)	*Helicotylenchus* spp. (66.66)	*X.insigne* (49.3)	*Trichodorus* spp. (31.3)		
Salvia spp.	*Helicotylenchus* spp. (101.6)	*Tylenchorynchus* spp. (66.6)	*Trichodorus* spp. (71.6)	*X.americanum* (42)		
Tagetes spp.	*Tylenchorynchus* spp. (44.6)	*X.americanum* (42.3)	*Helicotylenchus* spp. (39)	*Trichodorus* spp. (15)	*Pratylenchus* spp. (14)	*X.insigne* (8.66)
Zinnia spp.	*Trichodorus* spp. (72.6)	*Helicotylenchus* spp. (65.3)	*X.insigne* (58.3)	*X.americanum* (18.3)		

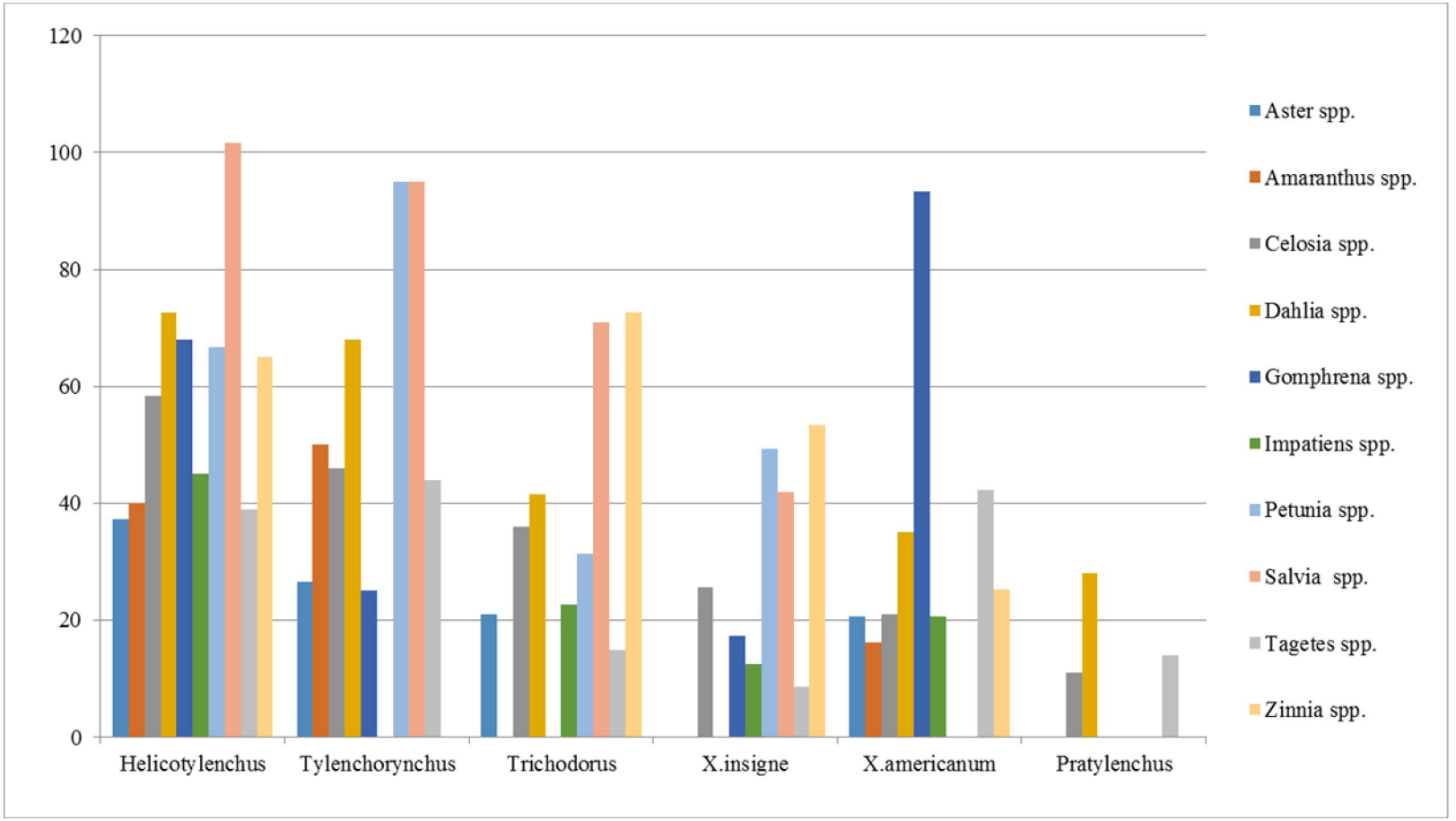


Fig. 2: Population density (per 250 cc soil) of pre-dominant plant parasitic nematodes on summer annuals in Nishat

4.2.3 Status of pre-dominat plant parasitic nematodes associated with summer annuals in Pari Mahal garden during summer season, 2020.

The basic data of 250 cc soil samples collected from ten flowers and the number of nematodes present in those samples is given in table 3. In all, six nematode species were found harbouring the rhizosphere of summer annuals *viz Helicotylenchus* spp., *Pratylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *Xiphinema insine* and *X.americanum*.Among the ten flowers shown in the table, two flowers *viz Dahlia* spp. *and Tagetes* spp. were found to be harbouring all the six species of nematodes unlike Chashma Shahi and among the nematodes, *Helicotylenchus* spp. was found on all the ten species of flowers, thereby showing the highest host range among all the six nematode species while the lowest host range was that of *Pratylenchus* spp. showing its presence on only two flowers. The highest populations of *Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *Xiphinema insine*, *X.americanum* and *Pratylenchus* spp. as revealed by table 3 were 293 (in 250 cc soil samples) on *Dahlia* spp., 220 (in 250cc soil samples) on *Salvia* spp., 189 (in 250cc soil samples) on *Salvia* spp., 173 (in 250cc soil samples) on *Petunia* spp., 178 (in 250cc soil samples) on *Gomphrena* spp. and 58 (in 250cc soil samples) on *Dahlia* spp. respectively.

After the species-wise analysis, the community structure of plant parasitic nematodes on summer annuals is presented in table 3a. The data presents the absolute density, relative density, absolute frequency, relative frequency and prominence value of plant parasitic nematodes on summer annuals which is discussed below.

***Aster* spp.:** The data revealed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 43.33 with 100 percent frequency. The per cent relative density of this species was recorded as 40.6 in comparison to other species with prominence value of 433. The absolute density of *Tylenchorhynchus* spp. was computed to be

24.00 with 66.66 percent frequency of occurance. The per cent relative density of this species was recorded as 22.5 in comparison to other species with prominence value of 195.8.

Trichodorus spp. had the absolute density of 18.3 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 19.6 in comparison to other species with prominence value of 149.4.The status of *X.americanum* with respect to absolute density was recorded as 21.00 with frequency of 33.33 percent. Its percent relative density was recorded as 17.2 in comparison to other species with prominence value of 121.2.

***Amaranthus* spp.:** The data revealed the association of three nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 53.6 with 100 percent frequency. The per cent relative density of this species was recorded as 41.6 in comparison to other species with prominence value of 536. The absolute density of *Tylenchorhynchus* spp. was computed to be 55.6 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 43.1 in comparison to other species with prominence value of 556. The status of *X.americanum* with respect to absolute density was recorded as 19.6 with frequency of 33.33 percent. Its percent relative density was recorded as 15.2 in comparison to other species with prominence value of 113.1.

***Celosia* spp.:** The data revealed the association of four nematodes out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 66.6 with 100 percent frequency. The per cent relative density of this species was recorded as 35.1 in comparison to other species with prominence value of 666. The absolute density of *Tylenchorhynchus* spp. was computed to be 64.00 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 33.2 in comparison to other species with prominence value of 332. *Trichodorus* spp. had the absolute density of 38.6 with percent

frequency of about 100. The percent relative density of this species was recorded as 20.3 in comparison to other species with prominence value of 386. The status of *X.americanum* with respect to absolute density was recorded as 20.3 with frequency of 33.33 percent. Its percent relative density was recorded as 10.7 in comparison to other species with prominence value of 60.9.

***Dahlia* spp.:** Dahlia showed the infestation of all the six nematodes. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 97.6 with 100 percent frequency. The per cent relative density of this species was recorded as 33.6 in comparison to other species with prominence value of 976. The absolute density of *Tylenchorhynchus* spp. was computed to be 62.6 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 21.6 in comparison to other species with prominence value of 626.*Trichodorus* spp. had the absolute density of 52.00 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 17.9 in comparison to other species with prominence value of 424.3. *X.insigne* had the absolute sensity of about 25.3 with percent frequency of about 66.66.Its relative density was computed as 8.7 with prominence value of about 206.4.Similarly, the absolute population densities of *X.americanum* and *Pratylenchus* spp. was recorded to be 33.3 and 19.3 with percent frequency of about 100 and 66.66 respectively. Their percent relative densities were recorded as 11.5 and 6.65 with prominence values of 333 and 157.5 respectively.

***Gomphrena* spp.:** The data revealed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *X. insigne* and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 54.3 with 100 percent frequency. The per cent relative density of this species was recorded as 31.2 in comparison to other species with prominence value of 543. The absolute density of *Tylenchorhynchus* spp. was computed to be 32.6 with 66.66 percent frequency of occurance. The per cent relative density of this species was recorded as 18.7 in comparison to other species with prominence

value of 266.01. *X.insigne* had the absolute density of 28.00 with percent frequency of about 100. The per cent relative density of this species was recorded as 16.1 in comparison to other species with prominence value of 280.The status of *X.americanum* with respect to absolute density was recorded to be as 59.3 with frequency of 100 percent. Its percent relative density was recorded as 34.04 in comparison to other species with prominence value of 593.

***Impatiens* spp.:** Out of six nematode species, four nematode species were found to be infecting this summer annual *viz Helicotylenchus* spp., *Trichodorus* spp., *X. insigne* and *X.americanum.* The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 32.33 with 66.66 percent frequency. The per cent relative density of this species was recorded as 35.5 in comparison to other species with prominence value of 263.8.The absolute density of *Trichodorus* spp. was computed to be 31.33 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 34.4 in comparison to other species with prominence value of 313.3. *X.insigne* had the absolute density of 13.00 with percent frequency of about 100. The per cent relative density of this species was recorded as 15.7 in comparison to other species with prominence value of 130.The status of *X.americanum* with respect to absolute density was recorded to be as 14.33 with frequency of 100 percent. Its percent relative density was recorded as 14.2 in comparison to other species with prominence value of 143.3.

***Petunia* spp.:** This summer annual also harboured four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.insigne.* The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 64.3 with 100 percent frequency. The per cent relative density of this species was recorded as 29.8 in comparison to other species with prominence value of 643. The absolute density of *Tylenchorhynchus* spp. was computed to be 70.6 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 32.1 in comparison to other species with prominence

value of 706. *Trichodorus* spp. had the absolute density of 41.00 with percent frequency of about 100. The per cent relative density of this species was recorded as 15.8 in comparison to other species with prominence value of 410.The status of *X.insigne* with respect to absolute density was recorded as 57.6 with frequency of 100 percent. Its percent relative density was recorded as 22.2 in comparison to other species with prominence value of 576.

***Salvia* spp.:** The data showed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 77.3 with 66.66 percent frequency. The per cent relative density of this species was recorded as 33.1 in comparison to other species with prominence value of 630.6. The absolute density of *Tylenchorhynchus* spp. was computed to be 73.3 with 100 percent frequency of occurance. The per cent relative densityof this species was recorded as 21.8 in comparison to other species with prominence value of 733. *Trichodorus* spp. had the absolute density of 63.00 with percent frequency of about 100. The per cent relative density of this species was recorded as 26.8 in comparison to other species with prominence value of 630.The status of *X.americanum* with respect to absolute density was recorded as 52.3 with frequency of 66.66 percent. Its percent relative density was recorded as 18.2 in comparison to other species with prominence value of 426.7.

***Tagetes* spp.:** This summer annual also showed the infestation of only four nematodes out of six unlike the previous two gardens *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 36.6 with 66.66 percent frequency. The per cent relative density of this species was recorded as 23.9 in comparison to other species with prominence value of 195.1. The absolute density of *Tylenchorhynchus* spp. was computed to be 53.00 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 34.8 in comparison to other species with prominence value of 530.*Trichodorus*

spp. had the absolute density of 19.00 with percent frequency of about 33.33. The per cent relative density of this species was recorded as 9.8 in comparison to other species with prominence value of 109.6. The status of *X.americanum* with respect to absolute density was recorded as 44.3 with frequency of 100 percent. Its percent relative density was recorded as 28.9 in comparison to other species with prominence value of 443.

***Zinnia* spp.:** Four nematode species were found to be infecting this summer annual *viz Helicotylenchus* spp., *Trichodorus* spp., *X. insigne* and *X.americanum.* The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 49.3 with 100 percent frequency. The per cent relative density of this species was recorded as 27.5 in comparison to other species with prominence value of 493.The absolute density of *Trichodorus* spp. was computed to be 62.3 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 34.7 in comparison to other species with prominence value of 623. *X.insigne* had the absolute density of 42.6 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 23.7 in comparison to other species with prominence value of 347.6.The status of *X.americanum* with respect to absolute density was recorded to be as 25.3 with frequency of 66.66 percent. Its percent relative density was recorded as 814.1 in comparison to other species with prominence value of 206.4.

4.2.3.1 Relative infestation of summer annuals to pre-dominant plant parasitic nematodes in Pari Mahal garden during summer season, 2020

After comparison of thirty soil samples of Pari Mahal garden collected from all ten flowers, the population density of pre-dominant plant parasitic nematodes are presented in descending order in Table 3b. This table shows a comparison in the occurance of each plant parasitic nematode on different summer annuals along with their absolute densities. Among all the ten flowers, *Helicotylenchus* spp. had the highest population density on *Dahlia* spp. (97.6 per

250 cc soil) and the lowest population density on *Tagetes* spp. (36.6 per 250 cc soil). *Tylenchorynchus* spp. showed the maximum population density on *Salvia* spp. (73.3 per 250 cc soil) and the lowest density on *Aster* spp. (24 per 250 cc soil). *Trichodorus* spp. had the highest population density on *Salvia* spp. (63 per 250 cc soil) and the lowest density on *Aster* spp. (18.3 per 250 cc soil). Similarly, *X. insigne* and *X. americanum* showed the maximum population densities on *Petunia* spp. (57.6 per 250 cc soil) and *Gomphrena* spp. (59.3 per 250 cc soil) respectively. *Pratylenchus* spp. was found on only one flower with population density of 19.3 per 250 cc soil on *Dahlia* spp.

Table 3: Pre-dominant plant parasitic nematodes (in 250 cc soil samples) associated with summer annuals in Pari Mahal garden during summer season, 2020

Flowers	No. of nematode species in 250cc soil samples					
	***Helicotylenchus* spp.**	***Tylenchorynchus* spp.**	***Trichodorus* spp.**	***X.insigne***	***X.americanum***	***Pratylenchus* spp.**
Aster spp.	130	72	55	-	63	-
Amaranthus spp.	161	167	-	-	59	-
Celosia spp.	200	192	116	-	61	-
Dahlia spp.	293	188	156	76	100	58
Gomphrena spp.	163	98	-	84	178	-
Impatiens spp.	190	-	125	58	97	-
Petunia spp.	193	212	123	173	-	-
Salvia spp.	232	220	189	-	157	-
Tagetes spp.	110	159	57	68	133	-
Zinnia spp.	148	-	187	128	76	-
Total	**1913**	**1308**	**1016**	**587**	**916**	**58**

Table 3a: Community analysis of pre-dominant plant parasitic nematodes associated with summer annuals in Pari Mahal garden during summer season, 2020

Flowers	Nematode species	AD	RD (%)	AF (%)	RF (%)	PV
Aster spp.	*Helicotylenchus* spp.	**43.3**	40.6	100	37.5	433
	Tylenchorynchus spp.	24	22.5	66.66	25	195.8
	Trichodorus spp.	18.3	19.6	66.66	25	149.4
	X.americanum	21	17.2	33.33	12.5	121.2
Amaranthus spp.	*Helicotylenchus* spp.	53.6	41.6	100	42.8	536
	Tylenchorynchus spp.	**55.6**	43.1	100	42.8	556
	X.americanum	19.6	15.2	33.33	14.3	113.1
Celosia spp.	*Helicotylenchus* spp.	**66.6**	35.1	100	21.4	666
	Tylenchorynchus spp.	64	33.2	100	21.4	332
	Trichodorus spp.	38.6	20.3	100	21.4	386
	X.americanum	20.3	10.7	33.33	7.14	60.9
Dahlia spp.	*Helicotylenchus* spp.	**97.6**	33.6	100	20	976
	Tylenchorynchus spp.	62.6	21.6	100	20	626
	Trichodorus spp.	52	17.9	66.66	13.3	424.3
	X.insigne	25.3	8.7	66.66	13.3	206.4
	X.americanum	33.3	11.5	100	20	333
	Pratylenchus spp.	19.3	6.65	66.66	13.3	157.5
Gomphrena spp.	*Helicotylenchus* spp.	54.3	31.2	100	27.3	543
	Tylenchorynchus spp.	32.6	18.7	66.66	18.2	266.01
	X.insigne	28	16.1	100	27.3	280
	X.americanum	**59.3**	34.04	100	27.3	593

Contd….

Table 3a: contd….

Flowers	Nematode species	AD	RD (%)	AF (%)	RF (%)	PV
Impatiens spp.	*Helicotylenchus* spp.	**32.33**	35.53	66.66	18.18	263.8
	Trichodorus spp.	31.33	34.43	100	27.27	313.3
	X. insigne	13	15.74	100	27.27	130
	X. americanum	14.33	14.28	100	27.27	143.3
Petunia spp.	*Helicotylenchus* spp.	64.3	29.8	100	25	643
	Tylenchorynchus spp.	**70.6**	32.1	100	25	706
	Trichodorus spp.	41	15.8	100	25	410
	X.insigne	57.6	22.2	100	25	576
Salvia spp.	*Helicotylenchus* spp.	**77.3**	33.1	66.66	19.9	630.6
	Tylenchorynchus spp.	73.3	21.8	100	30	733
	Trichodorus spp.	63	26.8	100	30	630
	X.americanum	52.3	18.2	66.66	19.9	426.7
Tagetes spp.	*Helicotylenchus* spp.	36.6	23.9	66.66	15.4	195.1
	Tylenchorynchus spp.	**53**	34.8	100	23.1	530
	Trichodorus spp.	19	9.8	33.33	7.6	109.6
	X.americanum	**44.3**	28.9	100	23.1	443
Zinnia spp.	*Helicotylenchus* spp.	49.3	27.5	100	30	493
	Trichodorus spp.	**62.3**	34.7	100	30	623
	X. insigne	42.6	23.7	66.66	19.9	347.6
	X. americanum	25.3	14.1	66.66	19.9	206.4

AD=Absolute density, RD=Relative density, AF=Absolute frequency, RF=Relative frequency, PV=Prominence value

Table 3b: Relative infestation of species of summer annuals to pre-dominant plant parasitic nematodes in Pari Mahal garden during summer season, 2020

Flower	Order of prevalence (AD) of nematodes in descending order					
Aster spp.	*Helicotylenchus* spp. (43.3)	*Tylenchorynchus* spp. (24.0)	*X.americanum* (21.0)	*Trichodorus* spp. (18.3)		
Amaranthus spp.	*Tylenchorynchus* spp. (55.6)	*Helicotylenchus* spp. (53.6)	*X.americanum* (19.6)			
Celosia spp.	*Helicotylenchus* spp. (66.6)	*Tylenchorynchus* spp. (64.0)	*Trichodorus* spp. (38.6)	*X.americanum* (20.3)		
Dahlia spp.	*Helicotylenchus* spp. (97.6)	*Tylenchorynchus* spp. (62.6)	*Trichodorus* spp. (52)	*X.americanum* (33.3)	*X.insigne* (25.3)	*Pratylenchus* spp. (19.3)
Gomphrena spp.	*X.americanum* (59.33)	*Helicotylenchus* spp. (54.3)	*Tylenchorynchus* spp. (32.6)	*X.insigne* (28)		

Contd….

Table 3b: contd….

Impatiens spp.	*Helicotylenchus* spp. (63.33)	*Trichodorus* spp. (41.6)	*X.americanum* (32.3)	*X.insigne* (19.3)		
Petunia spp.	*Tylenchorynchus* spp. (70.6)	*Helicotylenchus* spp. (64.3)	*X.insigne* (57.6)	*Trichodorus* spp. (41)		
Salvia spp.	*Helicotylenchus* spp. (77.3)	*Tylenchorynchus* spp. (73.3)	*Trichodorus* spp. (63)	*X.americanum* (52.3)		
Tagetes spp.	*Tylenchorynchus* spp. (53.0)	*X.americanum* (44.33)	*Helicotylenchus* spp. (36.6)	*Trichodorus* spp. (19.0)		
Zinnia spp.	*Trichodorus* spp. (62.3)	*Helicotylenchus* spp. (49.3)	*X.insigne* (42.6)	*X.americanum* (25.3)		

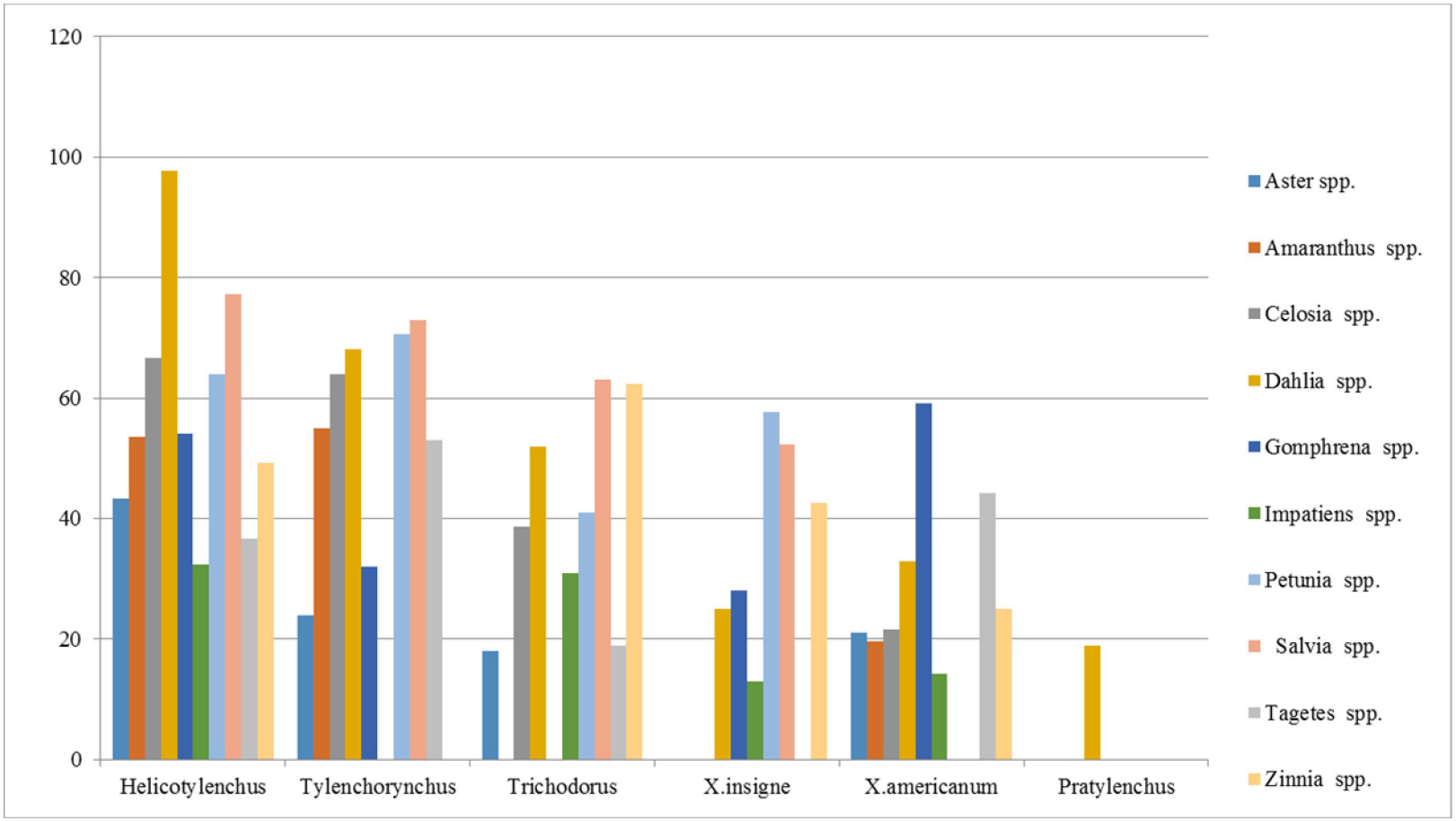


Fig. 3: Population density (per 250 cc soil) of pre-dominant plant parasitic nematodes on summer annuals in Pari Mahal

4.2.4 Status of pre-dominat plant parasitic nematodes associated with summer annuals in Shalimar garden during summer season, 2020.

The basic data of 250 cc soil samples collected from ten flowers and the number of nematodes present in those samples is given in table 4. In all, six nematode species were found harbouring the rhizosphere of summer annuals *viz Helicotylenchus* spp., *Pratylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *Xiphinema insine* and *X.americanum*. Among the ten flowers shown in the table, only one flower *viz Celosia* spp. was found to be harbouring all the six species of nematodes and among the nematodes, *Helicotylenchus* spp. was found on all the ten species of flowers, thereby showing the highest host range among all the six nematode species while the lowest host range was that of *Pratylenchus* spp. showing its presence on only two flowers. The highest populations of *Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *Xiphinema insine*, *X.americanum* and *Pratylenchus* spp. as revealed by table 4 were 278 (in 250 cc soil samples) on *Salvia* spp., 253 (in 250cc soil samples) on *Salvia* spp., 205 (in 250cc soil samples) on *Zinnia* spp., 111 (in 250cc soil samples) on *Zinnia* spp., 271 (in 250cc soil samples) on *Gomphrena* spp. and 83 (in 250cc soil samples) on *Tagetes* spp. respectively.

After the species-wise analysis, the community structure of plant parasitic nematodes on summer annuals is presented in table 4a. The data presents the absolute density, relative density, absolute frequency, relative frequency and prominence value of plant parasitic nematodes on summer annuals which is discussed below.

***Aster* spp.:** The data revealed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 35.00 with 100 percent frequency. The per cent relative density of this species was recorded as 31.9 in comparison to other species with prominence value of 350. The absolute density of *Tylenchorhynchus* spp. was computed to be

28.3 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 25.8 in comparison to other species with prominence value of 283.

Trichodorus spp. had the absolute density of 24.3 with percent frequency of about 33.33. The per cent relative density of this species was recorded as 22.2 in comparison to other species with prominence value of 140.2.The status of *X.americanum* with respect to absolute density was recorded as 22.00 with frequency of 100 percent. Its percent relative density was recorded as 20.1 in comparison to other species with prominence value of 220.

***Amaranthus* spp.:** The data revealed the association of three nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *X.insigne* and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 37.3 with 66.66 percent frequency. The per cent relative density of this species was recorded as 31.6 in comparison to other species with prominence value of 304.3. The absolute density of *Tylenchorhynchus* spp. was computed to be 55.3 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 46.9 in comparison to other species with prominence value of 553. The absolute density of *X.insigne* was computed to be 7.6 with 33.33 percent frequency of occurance. The per cent relative density of this species was recorded as 6.5 in comparison to other species with prominence value of 43.8. The status of *X.americanum* with respect to absolute density was recorded as 17.6 with frequency of 33.33 percent. Its percent relative density was recorded as 14.9 in comparison to other species with prominence value of 101.5.

***Celosia* spp.:** The data revealed the association of all the six nematodes. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 48.3 with 100 percent frequency. The per cent relative density of this species was recorded as 25.8 in comparison to other species with prominence value of 483. The absolute density of *Tylenchorhynchus* spp. was computed to be 43.3 with 66.66 percent frequency of occurance. The per cent relative density of this species was

recorded as 23.1 in comparison to other species with prominence value of 353.3. *Trichodorus* spp. had the absolute density of 33.3 with percent frequency of about 100. The percent relative density of this species was recorded as 17.8 in comparison to other species with prominence value of 333. The status of *X.insigne* with respect to absolute density was recorded as 23.6 with frequency of 100 percent. Its percent relative density was recorded as 12.6 in comparison to other species with prominence value of 236. Similarly, the absolute population densities of *X.americanum* and *Pratylenchus* spp. was recorded to be 22.6 and 16.00 with percent frequency of about 66.66 and 66.66 respectively. Their percent relative densities were recorded as 12.1 and 8.5 with prominence values of 184.4 and 130.5 respectively.

***Dahlia* spp.:** Dahlia showed the infestation of four nematodes *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 62.6 with 100 percent frequency. The per cent relative density of this species was recorded as 31.5 in comparison to other species with prominence value of 626. The absolute density of *Tylenchorhynchus* spp. was computed to be 57.6 with 66.66 percent frequency of occurance. The per cent relative density of this species was recorded as 29.1 in comparison to other species with prominence value of 470.*Trichodorus* spp. had the absolute density of 46.00 with percent frequency of about 100. The per cent relative density of this species was recorded as 19.5 in comparison to other species with prominence value of 460. Similarly, the absolute population density of *X.americanum* was recorded to be 32.00 with percent frequency of about 100. Its percent relative density was recorded as 13.6 with prominence values of 320.

***Gomphrena* spp.:** The data revealed the association of only three nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 56.00 with 100 percent frequency. The per cent relative density of this

species was recorded as 32.01 in comparison to other species with prominence value of 560. The absolute density of *Tylenchorhynchus* spp. was computed to be 28.6 with 66.66 percent frequency of occurance. The per cent relative density of this species was recorded as 14.3 in comparison to other species with prominence value of 233.4.The status of *X.americanum* with respect to absolute density was recorded to be highest as 90.3 with frequency of 100 percent. Its percent relative density was recorded as 45.4 in comparison to other species with prominence value of 903.

***Impatiens* spp.:** Out of six nematode species, four nematode species were found to be infecting this summer annual *viz Helicotylenchus* spp., *Trichodorus* spp., *X. insigne* and *X.americanum.*

The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 42.3 with 66.66 percent frequency. The per cent relative density of this species was recorded as 39.3 in comparison to other species with prominence value of 345.2.The absolute density of *Trichodorus* spp. was computed to be 29.6 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 27.7 in comparison to other species with prominence value of 296. *X.insigne* had the absolute density of 15.3 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 14.3 in comparison to other species with prominence value of 124.8.The status of *X.americanum* with respect to absolute density was recorded to be as 19.6 with frequency of 66.66 percent. Its percent relative density was recorded as 18.3 in comparison to other species with prominence value of 159.9.

***Petunia* spp.:** This summer annual also harboured four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp. and *Trichodorus* spp. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 70.00 with 100 percent frequency. The per cent relative density of this species was recorded as 30.3 in comparison to other species with prominence value of 700. The absolute density of *Tylenchorhynchus* spp. was computed to be 81.3 with 100

percent frequency of occurance. The per cent relative density of this species was recorded as 35.2 in comparison to other species with prominence value of 813. *Trichodorus* spp. had the absolute density of 39.3 with percent frequency of about 66.66. The per cent relative density of this species was recorded as 17.02 in comparison to other species with prominence value of 320.6.

***Salvia* spp.:** The data showed the association of four nematode species out of six *viz Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp. and *X.americanum*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 92.6 with 100 percent frequency. The per cent relative density of this species was recorded as 32.4 in comparison to other species with prominence value of 926. The absolute density of *Tylenchorhynchus* spp. was computed to be 84.3 with 66.66 percent frequency of occurance. The per cent relative density of this species was recorded as 22.4 in comparison to other species with prominence value of 687.8. *Trichodorus* spp. had the absolute density of 64.00 with percent frequency of about 100. The per cent relative density of this species was recorded as 29.5 in comparison to other species with prominence value of 640.The status of *X.americanum* with respect to absolute density was recorded as 44.3 with frequency of 100 percent. Its percent relative density was recorded as 15.5 in comparison to other species with prominence value of 443.

***Tagetes* spp.:** This summer annual showed the infestation of all the five nematodes except *X.insigne*. The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 35.3 with 100 percent frequency. The per cent relative density of this species was recorded as 20.3 in comparison to other species with prominence value of 353. The absolute density of *Tylenchorhynchus* spp. was computed to be 41.00 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 22.3 in comparison to other species with prominence value of 410.*Trichodorus* spp. had the absolute density of 10.6 with percent frequency of about 33.33. The per cent relative density of this species was recorded as 5.06 in comparison to other species with prominence

value of 61.2.Similarly, the absolute population densities of *X.americanum* and *Pratylenchus* spp. was recorded to be 46.6 and 27.6 with percent frequency of about 100 and 66.66 respectively. Their percent relative densities were recorded as 31.3 and 13.2 with prominence values of 426 and 225.2 respectively

***Zinnia* spp.:** Four nematode species were found to be infecting this summer annual *viz Helicotylenchus* spp., *Trichodorus* spp., *X. insigne* and *X.americanum.* The absolute density per 250 cc soil of *Helicotylenchus* spp. was recorded as 58.3 with 100 percent frequency. The per cent relative density of this species was recorded as 31.5 in comparison to other species with prominence value of 583.The absolute density of *Trichodorus* spp. was computed to be 68.3 with 100 percent frequency of occurance. The per cent relative density of this species was recorded as 36.9 in comparison to other species with prominence value of 683. *X.insigne* had the absolute density of 37.00 with percent frequency of about 100. The per cent relative density of this species was recorded as 20.04 in comparison to other species with prominence value of 370.The status of *X.americanum* with respect to absolute density was recorded to be as 21.00 with frequency of 66.66 percent. Its percent relative density was recorded as 11.4 in comparison to other species with prominence value of 171.4.

4.2.4.1 Relative infestation of summer annuals to pre-dominant plant parasitic nematodes in Shalimar garden during summer season, 2020.

After comparison of thirty soil samples of Shalimar garden collected from all ten flowers, the population density of pre-dominant plant parasitic nematodes are presented in descending order in Table 4b. Among all the ten flowers, *Helicotylenchus* spp. had the highest population density on *Salvia* spp. (92.6 per 250 cc soil) and the lowest population density on *Aster* spp. (35 per 250 cc soil). *Tylenchorynchus* spp. showed the maximum population density on *Petunia* spp. (84.3 per 250 cc soil) and the lowest density on *Aster* spp. (28.3 per 250 cc soil). *Trichodorus* spp. had the highest population density on *Zinnia* spp. (68.3 per 250 cc soil) and the lowest density on *Tagetes* spp. (10.6 per 250 cc soil). Similarly, *X.*

insigne and *X. americanum* showed the maximum population densities on *Zinnia* spp. (37 per 200 cc soil) and *Gomphrena* spp. (90.3 per 250 cc soil) respectively. *Pratylenchus* spp. was found on only two flowers with its maximum population density on *Tagetes* spp. (27.6 per 250 cc soil).

Table 4: Pre-dominant plant parasitic nematodes (in 250 cc soil samples) associated with summer annuals in Shalimar garden during summer season, 2020

	No. of nematode species in 250cc soil samples					
Flowers	*Helicotylenchus* spp.	*Tylenchorynchus* spp.	*Trichodorus* spp.	*X.insigne*	*X.americanum*	*Pratylenchus* spp.
Aster spp.	105	85	73	-	66	-
Amaranthus spp.	112	166	-	23	53	-
Celosia spp.	145	130	100	71	68	48
Dahlia spp.	188	173	138	-	96	-
Gomphrena spp.	168	86	-	-	271	-
Impatiens spp.	127	-	89	46	59	-
Petunia spp.	210	244	118	-	-	-
Salvia spp.	278	253	192	-	133	-
Tagetes spp.	106	123	32	-	140	83
Zinnia spp.	175	-	205	111	63	-
Total	**1614**	**1260**	**947**	**251**	**949**	**131**

Table 4a: Community analysis of pre-dominant plant parasitic nematodes associated with summer annuals in Shalimar garden during summer season, 2020

Flowers	Nematode species	AD	RD (%)	AF (%)	RF (%)	PV
Aster spp.	*Helicotylenchus* spp.	**35**	31.9	100	30	350
	Tylenchorynchus spp.	28.3	25.8	100	30	283
	Trichodorus spp.	24.3	22.2	33.33	9.9	140.2
	X.americanum	22	20.1	100	30	220
Amaranthus spp.	*Helicotylenchus* spp.	37.3	31.6	66.66	28.5	304.3
	Tylenchorynchus spp.	**55.3**	46.9	100	42.8	553
	X.insigne	7.6	6.5	33.33	14.2	43.8
	X.americanum	17.6	14.9	33.33	14.2	101.5
Celosia spp.	*Helicotylenchus* spp.	**48.3**	25.8	100	20	483
	Tylenchorynchus spp.	43.3	23.1	66.66	13.3	353.3
	Trichodorus spp.	33.3	17.8	100	20	333
	X.insigne	23.6	12.6	100	20	236
	X.americanum	22.6	12.1	66.66	13.3	184.4
	Pratylenchus spp.	16	8.5	66.66	13.3	130.5
Dahlia spp.	*Helicotylenchus* spp.	**62.6**	31.5	100	27.3	626
	Tylenchorynchus spp.	57.6	29.1	66.66	19.7	470
	Trichodorus spp.	46	19.5	100	27.3	460
	X.americanum	32	13.6	100	27.3	320
Gomphrena spp.	*Helicotylenchus* spp.	56	32.01	100	37.5	560
	Tylenchorynchus spp.	28.6	14.3	66.66	24.9	233.4
	X.americanum	**90.3**	45.4	100	37.5	903

Contd….

Table 4a: contd…

Impatiens spp.	*Helicotylenchus* spp.	**42.3**	39.3	66.66	22.22	345.2
	Trichodorus spp.	29.6	27.7	100	33.33	296
	X. insigne	15.3	14.3	66.66	22.22	124.8
	X. americanum	19.6	18.3	66.66	22.22	159.9
Petunia spp.	*Helicotylenchus* spp.	70	30.3	100	37.5	700
	Tylenchorynchus spp.	**81.3**	35.2	100	37.5	813
	Trichodorus spp.	39.3	17.02	66.66	24.9	320.6
Salvia spp.	*Helicotylenchus* spp.	**92.6**	32.4	100	27.2	926
	Tylenchorynchus spp.	84.3	22.4	66.66	18.2	687.8
	Trichodorus spp.	64	29.5	100	27.2	640
	X.americanum	44.3	15.5	100	27.2	443
Tagetes spp.	*Helicotylenchus* spp.	35.3	20.3	100	21.4	353
	Tylenchorynchus spp.	**41**	22.3	100	21.4	410
	Trichodorus spp.	10.6	5.06	33.33	7.14	61.2
	X.americanum	46.6	31.3	100	21.4	426
	Pratylenchus spp.	27.6	13.2	66.66	14.2	225.2
Zinnia spp.	*Helicotylenchus* spp.	58.3	31.5	100	27.2	583
	Trichodorus spp.	**68.3**	36.9	100	27.2	683
	X. insigne	37	20.04	100	27.2	370
	X. americanum	21	11.4	66.66	18.2	171.4

AD=Absolute density, RD=Relative density, AF=Absolute frequency, RF=Relative frequency, PV=Prominence value

Table 4b: Relative infestation of species of summer annuals to pre-dominant plant parasitic nematodes in Shalimar garden during summer season, 2020

Flower	Order of prevelance (AD) of nematodes in descending order					
Aster spp.	*Helicotylenchus* spp. (35.0)	*Tylenchorynchus* spp. (28.3)	*Trichodorus* spp. (24.3)	*X.americanum* (22)		
Amaranthus spp.	*Tylenchorynchus* spp. (55.3)	*Helicotylenchus* spp. (37.3)	*X.americanum* (17.6)	*X.insigne* (7.66)		
Celosia spp.	*Helicotylenchus* spp. (48.3)	*Tylenchorynchus* spp. (43.33)	*Trichodorus* spp. (33.33)	*X.insigne* (23.66)	*X.americanum* (22.6)	*Pratylenchus* spp. (16.0)
Dahlia spp.	*Helicotylenchus* spp. (62.6)	*Tylenchorynchus* spp. (57.6)	*Trichodorus* spp. (46)	*X.americanum* (32)		
Gomphrena spp.	*X.americanum* (90.3)	*Helicotylenchus* spp. (56)	*Tylenchorynchus* spp. (28.6)			

Contd….

Table 4b: contd….

Impatiens spp.	*Helicotylenchus* spp. (42.33)	*Trichodorus* spp. (29.6)	*X.americanum* (19.6)	*X.insigne* (15.3)		
Petunia spp.	*Tylenchorynchus* spp. (81.3)	*Helicotylenchus* spp. (70.0)	*Trichodorus* spp. (39.3)			
Salvia spp.	*Helicotylenchus* spp. (92.6)	*Tylenchorynchus* spp. (84.3)	*Trichodorus* spp. (64.0)	*X.americanum* (44.3)		
Tagetes spp.	*Tylenchorynchus* spp. (41.0)	*X.americanum* (46.6)	*Helicotylenchus* spp. (35.3)	*Pratylenchus* spp. (27.6)	*Trichodorus* spp. (10.66)	
Zinnia spp.	*Trichodorus* spp. (68.3)	*Helicotylenchus* spp. (58.3)	*X.insigne* (37.0)	*X.americanum* (21.0)		

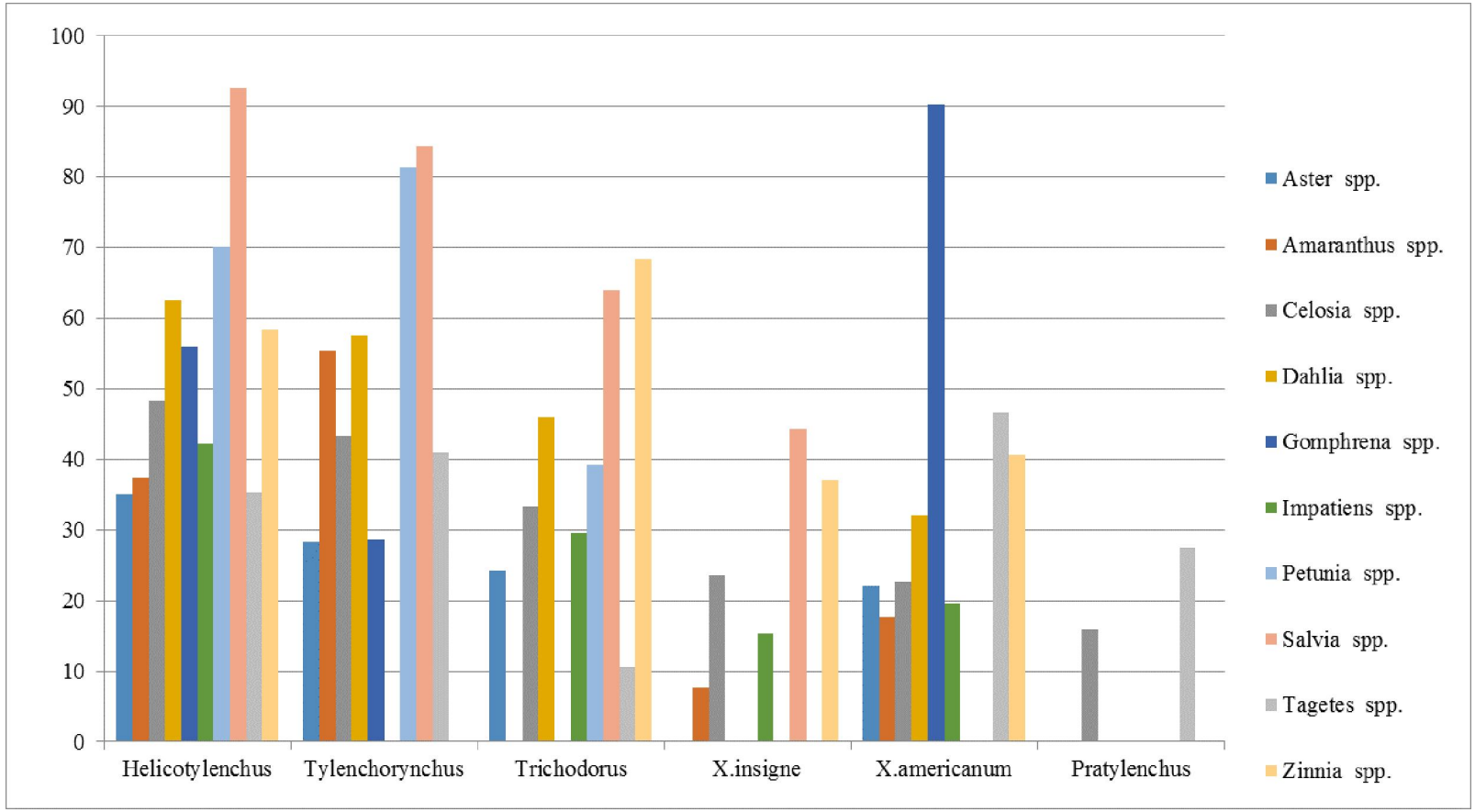


Fig. 4: Population density (per 250 cc soil) of pre-dominant plant parasitic nematodes on summer annuals in Shalimar.

4.2.5 Status of pre-dominat plant parasitic nematodes associated with summer annuals in Mughal Gardens during summer season, 2020.

After comparing one hundred twenty samples of all the four gardens and computing means of absolute density, absolute frequency, relative density, relative frequency and prominence value, the data revealed, as presented in table 6 is discussed below:

***Aster* spp.:** The data reveals that *Helicotylenchus* spp. stands as first pre-dominant plant parasitic nematode with absolute density about 47.4, frequency 91.66 and prominence value of 456.9. *Tylenchorynchus* spp. stands second with absolute density 27.6, frequency 91.66 and prominence value of 265.2.*Trichodorus* spp. and *X.americanum* had the absolute density of 21.8 and 23.4, frequency of 58.3 and 83.3 and prominence value of 168.8 and 208.1 respectively. Although table 6 reveals *Helicotylenchus* spp. as first pre-dominant plant parasitic nematode but on the basis of total biomass and relative biomass, *X.americanum* stands first with highest total biomass (37.4) and relative biomass (35.3). Table 6 also reveals the importance value and pathogenicity of pre-dominant plant parasitic nematodes. On *Aster* spp. *Helicotylenchus* spp. stands first in terms of rank of importance (83.7), *X.americanum* stands second (79.4), *Tylenchorynchus* spp. stands third (63.8) and *Trichodorus* spp. stands fourth (44.8).

***Amaranthus* spp.:** The data reveals that *Tylenchorynchus* spp. stands as first pre-dominant plant parasitic nematode with absolute density about 51.9, frequency 100 and prominence value of 514.7. *Helicotylenchus* spp. stands second with absolute density 41.5, frequency 91.66 and prominence value of 426.5. *X.insigne* and *X.americanum* had the absolute density of 11.2 and 17.7, frequency of 44.9 and 58.3 and prominence value of 110.6 and 133.5 respectively. On the basis of total biomass and relative biomass, *X.insigne* stands first with highest total biomass (31.02) and relative biomass (29.5). In terms of in terms of importance value, *Tylenchorynchus* spp. stands first (106.1), *Helicotylenchus* spp. stands

second (80.7), *X.americanum* stands third (60.63) and *X.insigne* stands fourth (58.8).

***Celosia* spp.:** Since this summer annual showed the infestation of all the six nematodes, the most dominant plant parasitic nematode was *Helicotylenchus* spp. with highest absolute density of about 61.6. The frequency and prominence value of this nematode as shown by the data are about 91.66 and 639.6 respectively. *Tylenchorynchus* spp. stands second with absolute density of 51.2, frequency 91.66 and prominence value of 375.6. *Trichodorus* spp. has the absolute density of 34.5, frequency about 91.66 and prominence value of 329. The status of *X.insigne and X.americanum* in terms of absolute density and frequency is 24.9, 66.66 and 18.6 and 58.3 respectively. *Pratylenchus* spp. stands last in terms of absolute density (11.6) and prominence value (96.2).

On the basis of total biomass, *X.insigne* stands first (52.7) and *Pratylenchus* spp. stands last (3.9). However, *Helicotylenchus* spp. stands first in terms of importance value (65.7) followed by *Tylenchorynchus* spp. (62.1). *X.insigne*, *Trichodorus* spp. and *X.americanum* stand third, fourth and fifth with importance values of about 58.8, 50.2 and 43.8 respectively. *Pratylenchus* spp. stands sixth with importance value of 18.3.

***Dahlia* spp.:** Since this summer annual also showed the infestation of all the six nematodes, the most dominant plant parasitic nematode was *Helicotylenchus* spp. with highest absolute density of about 86.9. The frequency and prominence value of this nematode as shown by the data are about 100 and 869.5 respectively. *Tylenchorynchus* spp. stands second with absolute density of 69.8, frequency 91.66 and prominence value of 672.5. *Trichodorus* spp. has the absolute density of 54.7, frequency about 83.33 and prominence value of 504.2. The status of *X.insigne and X.americanum* in terms of absolute density and frequency is 30.5, 44.4 and 31.2 and 100 respectively. *Pratylenchus* spp. stands last in terms of absolute density (23.8) and prominence value (214.6). On the basis of total biomass, *X.americanum* stands first (53.1) and *Pratylenchus* spp. stands last (5.8).

However, *Helicotylenchus* spp. stands first in terms of importance value (67.7) followed by *Tylenchorynchus* spp. (64.2). *X.americanum*, *Trichodorus* spp. and *X.insigne* stand third, fourth and fifth with importance values of about 63.7, 46.5 and 29.6 respectively. *Pratylenchus* spp. stands sixth with importance value of 26.7.

***Gomphrena* spp.:** This summer annual showed the highest infestation of *X.americanum* in terms of absolute density (81.5) with frequency and prominence value of 100 and 815.5 respectively. *Helicotylenchus* spp. stands second with absolute density of 54.9, frequency of occurance about 91.66 and prominence value of 530.1. *Tylenchorynchus* spp. stands third with absolute density of 26.4, frequency of occurance about 74.9 and prominence value of 224.2. *X.insigne* stands last with absolute density of 19.3, frequency of occurance about 74.9 and prominence value of 183.6. On the basis of total biomass, *X.americanum* stands first (130.4) and *Tylenchorynchus* spp. stands last (9.7). Moreover, *X.americanum* stands first in terms of importance value (138.9) followed by *Helicotylenchus* spp. (65.8). *X.insigne* and *Tylenchorynchus* spp. stand third and fourth with importance values of about 53.1 and 41.6 respectively.

***Imptiens* spp.:** The data reveals that *Helicotylenchus* spp. stands as first pre-dominant plant parasitic nematode with absolute density about 45.7, frequency 83.3 and prominence value of 423. *Trichodorus* spp. stands second with absolute density 31.3, frequency 91.66 and prominence value of 302.4. *X.americanum* and *X.insigne* stand third and fourth with absolute density of 21.7 and 15.5, frequency of 74.9 and 66.66 and prominence value of 183.7 and 121.2 respectively. On the basis of total biomass, *X.americanum* stands first with highest total biomass (36.8) and *Trichodorus* spp. stands last with total biomass of about 15.However, *Helicotylenchus* spp. stands first in terms of rank of importance (82.7), *X.americanum* stands second (79.0), *Trichodorus* spp. stands third (72.0) and *X.insigne* stands fourth (68.5).

***Petunia* spp.:** On this summer annual, *Tylenchorynchus* spp. stands as first pre-

dominant plant parasitic nematode with absolute density about 88.1, frequency 91.66 and prominence value of 853.5. *Helicotylenchus* spp. stands second with absolute density 71.3, frequency 100 and prominence value of 744.3. *X insigne* and *Trichodorus* spp. stand third and fourth with absolute density of 47.7 and 36.7, frequency of 88.8 and 83.3 and prominence value of 454.3 and 332.9 respectively. On the basis of total biomass, *X.insigne* stands first with highest total biomass (99.6) and *Trichodorus* spp. stands last with total biomass of about 17.6. Moreover, *X.insigne* stands first in terms of rank of importance (100.8), *Tylenchorynchus* spp. stands second (85.6), *Helicotylenchus* spp. stands third (68.8) and *Trichodorus* spp. stands fourth (47.1).

***Salvia* spp.:** The data reveals that *Helicotylenchus* spp. stands as first pre-dominant plant parasitic nematode with absolute density about 86.5, frequency 91.66 and prominence value of 866.4. *Tylenchorynchus* spp. stands second with absolute density 78.2, frequency 91.66 and prominence value of 711.3.*Trichodorus* spp. and *X.americanum* have the absolute density of 63.15 and 41.55, frequency of 100 and 83.3 and prominence value of 602.1 and 403.7 respectively. Although table 6 reveals *Helicotylenchus* spp. as first pre-dominant plant parasitic nematode but on the basis of total biomass and relative biomass, *X.americanum* stands first with highest total biomass (66.4) and relative biomass (39.7). *Tylenchorynchus* spp. stands first in terms of rank of importance (78.8), *X.americanum* stands second (74.7), *Helicotylenchus* spp. stands third (74.3) and *Trichodorus* spp. stands fourth (69.3).

***Tagetes* spp.:** The most dominant plant parasitic nematode on this summer annual was *Tylenchorynchus* spp. with highest absolute density of about 44.6. The frequency and prominence value of this nematode as shown by the data are about 100 and 460.5 respectively. *X.americanum* stands second with absolute density of 42.6, frequency 100 and prominence value of 473.8. *Helicotylenchus* spp. has the absolute density of 34.5, frequency about 83.33 and prominence value of 308.9. The status of *Pratylenchus* spp. and *Trichodorus* spp.in terms of absolute density

and frequency is 20.4, 12.8 and 55.5 and 41.66 respectively. *X.insigne* stands last in terms of absolute density (10.6) and prominence value (117.5). On the basis of total biomass, *X.americanum* stands first (68.2) and *Trichodorus* spp. stands last (5.12). Moreover, *X.americanum* stands first in terms of importance value (96.5) followed by *Tylenchorynchus* spp. (66.5). *Helicotylenchus* spp., *X.insigne* and *Pratylenchus* spp. stand third, fourth and fifth with importance values of about 45.4, 41.2 and 29.7 respectively. *Trichodorus* spp. stands sixth with importance value of 20.4.

***Zinnia* spp.:** The data reveals that *Trichodorus* spp. stands as first pre-dominant plant parasitic nematode with absolute density about 70.3, frequency 100 and prominence value of 703. *Helicotylenchus* spp. stands second with absolute density 59.1, frequency 91.66 and prominence value of 561.3. *X insigne* and *X. americanum*. stand third and fourth with absolute density of 43.4 and 19.8, frequency of 83.3 and 49.9 and prominence value of 309.2 and 222.5 respectively. On the basis of total biomass, *X.insigne* stands first with highest total biomass (95.5) and *Helicotylenchus* spp. stands last with total biomass of about 23.6.Moreover, *X.insigne* stands first in terms of importance value (101.4), *Trichodorus* spp. stands second, *Helicotylenchus* spp. stands third and *X. americanum*. Stands fourth with importance values of about 83.9, 72 and 43.1 respectively.

Table 5: Nematode measurement (µm) for the estimation of biomass of plant parasitic nematodes in Mughal Gardens, Srinagar

Flower	Nematode species	Length (L)				Width (W)				Mean (L)	Mean (W)
		1	2	3	4	1	2	3	4		
Aster spp.	*Helicotylenchus* spp.	1250.8	1248.3	1234.2	1230.2	22.35	22.4	21.8	21.5	**1240.8**	**22.01**
	Tylenchorynchus spp.	1349.7	1255.6	1233.8	1326.2	27.8	23.8	25.01	26.2	**1291.3**	**25.7**
	Trichodorus spp.	874.3	890	795.2	885.6	31.8	27.2	29.6	30.2	**861.3**	**29.7**
	X.americanum	2030.5	2296	2154.8	1750	39.01	35.5	35.3	34.8	**2057.8**	**36.2**
Amaranthus spp.	*Helicotylenchus* spp.	1230.7	1153.8	1187	1238.5	19.63	22.6	22.7	20.9	**1202.5**	**21.45**
	Tylenchorynchus spp.	348.6	1350.1	1254.3	1252.5	27.5	25.2	24.5	26.3	**1301.3**	**25.87**
	X.insigne	2483.8	2450	2487.7	2349.5	36.9	37.82	38.6	39.01	**2442.7**	**38.08**
	X.americanum	2030.5	2296	2154.8	2050.3	39.01	35.5	35.3	36.3	**2132.9**	**36.5**
Celosia spp.	*Helicotylenchus* spp.	1131.8	1183.4	1245.7	1235.9	18.05	19.2	22.01	22.6	**1199.2**	**20.46**
	Tylenchorynchus spp.	1256.2	1318.2	1251.3	1232.5	24.3	25.2	23.8	25.4	**1264.5**	**24.6**
	Trichodorus spp.	883.3	968.6	970	965.3	28.8	29.6	30.2	29.5	**946.8**	**29.5**
	X.insigne	2440.2	2487.5	2532	2321.6	38.3	36.7	38.4	35.2	**2445.3**	**37.2**
	X.americanum	2043.2	2194.3	2280	2040	36.2	36.7	38.4	38.01	**2139.4**	**37.3**
	Pratylenchus spp.	845.3	835.1	750.8	820.6	25.2	24.01	24.5	23.8	**812.9**	**24.3**

Contd…

Table 5: contd….

Flower	Nematode species	Length (L)				Width (W)				Mean (L)	Mean (W)
		1	2	3	4	1	2	3	4		
Dahlia spp.	*Helicotylenchus* spp.	1154.2	1224.8	1182.9	1235	22.2	21.6	21.7	22.01	**1199.23**	**21.8**
	Tylenchorynchus spp.	1355	1233.8	1257	1345	26.5	24.6	25.5	25.3	**1297.7**	**25.4**
	Trichodorus spp.	879.2	790.6	865.2	970	27	26.3	27.3	28.0	**876.2**	**27.2**
	X.insigne	2451	2482	2547	2466	38.5	37.1	36.3	39.6	**2486.5**	**37.8**
	X.americanum	2187.2	2250	2229.5	2190.5	36.3	34.5	35.4	37.4	**2243.3**	**35.6**
	Pratylenchus spp.	832	846	823.4	875.5	24.1	23.8	23.01	20.09	**844.22**	**22.75**
Gomphrena spp.	*Helicotylenchus* spp.	1186.5	1197.6	1230	1231.2	22.38	22.4	23.01	19.4	**1211.3**	**21.7**
	Tylenchorynchus spp.	1249.2	1351.2	1287.8	1245.2	27.3	28.6	24.7	25.19	**1283.4**	**21.6**
	X.insigne	2520	2470.5	2347.3	2465.6	37.1	38.4	36.6	34.2	**2450.8**	**36.5**
	X.americanum	2294.5	2143.3	1752	1820.6	34.5	35.2	38.3	35.4	**2002.6**	**35.8**
Impatiens spp.	*Helicotylenchus* spp	1243.2	1230.2	1156.5	1190	21.5	22.3	21.8	21.6	**1204.9**	**21.8**
	Trichodorus spp	966.3	889.4	798.3	874.3	30.5	27.5	29.3	26.8	**882.07**	**28.5**
	X.insigne	2497	2458.4	2344.6	2452.8	37.6	35.4	39.01	34.8	**2438.2**	**36.7**
	X.americanum	2278.8	2293.1	1784	2189.6	38.6	34.2	35.9	35.3	**2136.3**	**36**

Contd…

Table 5: contd….

Flower	Nematode species	Length (L)				Width (W)				Mean (L)	Mean (W)
		1	2	3	4	1	2	3	4		
Petunia spp.	*Helicotylenchus* spp	1240.4	1172.3	1115.3	1236.5	20.5	18.76	21.8	22.1	**1191.1**	**20.7**
	Tylenchorynchus spp	1257.3	1330.7	1248.5	1264.6	25.03	24.5	22.9	27.5	**1275.3**	**24.9**
	Trichodorus spp	888	878.5	960.5	785.5	30.5	29.8	31.2	27.3	**878.1**	**29.7**
	X.insigne	2351.4	2453.4	2496	2487.6	39.01	38.62	34.6	36.5	**2447.1**	**37.01**
Salvia spp.	*Helicotylenchus* spp	1170.5	1145.6	1240.1	1154	18.3	21.6	22.99	21.7	**1177.5**	**21.1**
	Tylenchorynchus spp	1360.3	1347.3	1264.7	1273.2	25.4	23.02	26.4	27.8	**1311.3**	**25.6**
	Trichodorus spp	846.2	945.6	868.5	954	30.2	29.2	27.3	28.5	**903.5**	**28.8**
	X.americanum	2190.2	2038.5	2193	1789.4	34.5	33.8	39.4	35.8	**2052.7**	**35.8**
Tagetes spp.	*Helicotylenchus* spp	1287.3	1194.2	1234.3	1150.2	21.8	19.8	20.4	18.3	**1216.5**	**20.1**
	Tylenchorynchus spp	1349.4	1278.4	1273	1348.3	25.3	24.7	26.09	27.1	**1312.2**	**25.8**
	Trichodorus spp	865.3	785.3	850.4	932.3	30.2	27.09	28.1	29.4	**858.32**	**28.6**
	X.insigne	2449.2	2541.4	2390.6	2243.8	38.2	36.9	34.8	35.2	**2406.7**	**36.2**
	X.americanum	2183.3	2274.5	1884.6	1935.9	38.7	33.3	35.6	34.8	**2069.5**	**35.6**
	Pratylenchus spp	816.6	790.5	756.4	853.2	20.6	24.5	24.1	22.4	**804.2**	**22.9**
Zinnia spp.	*Helicotylenchus* spp	1235.3	1228	1190.2	1136.7	20.6	22.3	22.06	21.98	**1197.5**	**21.7**
	Trichodorus spp	950.1	789	964.8	873.8	31.2	27.2	26.6	28.1	**894.4**	**28.2**
	X.insigne	2501.5	2496.3	2468.3	2500	38.9	36.5	37.3	36.8	**2491.5**	**37.3**
	X.americanum	2257.3	1880.6	2234.5	1772	35.2	34.8	36.7	34.5	**2036.1**	**35.3**

L= length of nematode and B= breadth of nematode

Table 6: Diversity and community structure including Biomass and Importance value of plant parasitic nematodes associated with summer annuals in Mughal gardens, Srinagar

Flower	Nematode species	Cumulative mean of all the gardens								
		A.D	R.D	A.F	R.F	P.V	G/nem (µg)	T.G (µg)	R.G	I.V
Aster spp.	*Helicotylenchus* spp.	47.4	38.55	91.66	28.6	456.9	0.37	17.5	16.3	**83.7**
	Tylenchorynchus spp.	27.6	23.2	91.66	28.07	265.2	0.53	13.8	12.4	63.8
	Trichodorus spp.	21.8	19.01	58.3	18.25	168.8	0.4	8.7	7.5	44.8
	X.americanum	23.4	19.2	83.3	24.9	208.1	1.6	37.4	35.3	**79.4**
Amaranthus spp.	*Helicotylenchus* spp.	41.5	35.4	91.66	29.7	426.5	0.35	14.5	13.7	80.7
	Tylenchorynchus spp.	51.9	44.5	100	33.4	514.7	0.54	29.6	28.2	**106.1**
	X.insigne	11.2	9.6	44.9	18.6	110.6	2.2	31.02	29.5	58.8
	X.americanum	17.79	15.3	58.3	18.1	133.5	1.7	30.02	28.5	60.63
Celosia spp.	*Helicotylenchus* spp.	61.6	32.1	91.66	20.3	639.6	0.31	20.5	13.3	**65.7**
	Tylenchorynchus spp.	51.2	26.3	91.66	20.7	375.6	0.5	25.6	16.6	62.1
	Trichodorus spp.	34.5	18.3	91.66	20.5	329	0.51	17.5	11.4	50.2
	X.insigne	24.9	10.6	66.66	14.0	192.8	2.1	52.7	34.2	58.8
	X.americanum	18.6	9.0	58.3	13.1	139.8	1.8	33.5	21.7	43.8
	Pratylenchus spp.	11.6	6.1	44.9	9.7	96.2	0.3	3.96	2.5	18.3

Contd…..

Table 6: contd…..

Flower	Nematode species	Cumulative mean of all the gardens								
		A.D	**R.D**	**A.F**	**R.F**	**P.V**	**G/nem (µg)**	**T.G (µg)**	**R.G**	**I.V**
Dahlia spp.	*Helicotylenchus* spp.	86.95	29.4	100	19.1	869.5	0.35	30.4	19.2	**67.7**
	Tylenchorynchus spp.	69.8	23.8	91.66	17.5	672.5	0.52	36.3	22.9	64.2
	Trichodorus spp.	54.7	18.4	83.33	14.2	504.2	0.4	21.8	13.7	46.5
	X.insigne	30.5	9.1	44.4	12.7	216.4	2.2	11.4	7.2	29.6
	X.americanum	31.22	11.1	100	19.06	312.3	1.7	53.1	33.5	63.7
	Pratylenchus spp.	23.8	7.4	77.7	15.8	214.6	0.27	5.8	3.6	26.7
Gomphrena spp.	*Helicotylenchus* spp.	54.9	29.7	91.66	26.6	530.1	0.35	19.2	9.5	65.8
	Tylenchorynchus spp.	26.4	14.4	74.9	22.4	224.2	0.37	9.7	4.8	41.6
	X.insigne	19.3	11.2	74.9	21.3	183.6	2.04	41.4	20.6	53.1
	X.americanum	81.5	44.6	100	29.5	815.5	1.6	130.4	64.9	**138.9**
Impatiens spp.	*Helicotylenchus* spp.	45.7	39.9	83.3	26.9	423.0	0.35	15.9	15.9	**82.7**
	Trichodorus spp.	31.3	27.6	91.66	28.8	302.4	0.5	15.6	15.6	72.0
	X.insigne	15.5	13.3	66.66	20.5	121.2	2.05	31.7	31.7	68.5
	X.americanum	21.7	18.7	74.9	23.5	183.7	1.7	36.8	36.8	79.0
Petunia spp.	*Helicotylenchus* spp.	71.3	29.6	100	27.3	744.3	0.29	21.5	11.7	68.8
	Tylenchorynchus spp.	88.1	36.5	91.6	24.8	853.5	0.49	44.6	24.3	85.6
	Trichodorus spp.	36.7	14.7	83.33	22.8	332.9	0.48	17.6	9.6	47.1
	X.insigne	47.7	19.1	88.8	24.8	454.3	2.09	99.6	54.3	**100.8**

Contd…..

Table 6: contd…..

Flower	Nematode species	Cumulative mean of all the gardens								
		A.D	**R.D**	**A.F**	**R.F**	**P.V**	**G/nem (µg)**	**T.G (µg)**	**R.G**	**I.V**
Salvia spp.	*Helicotylenchus* spp.	86.5	33.2	91.6	24.8	866.4	0.3	27.3	16.3	74.3
	Tylenchorynchus spp.	78.2	23.7	91.6	25.1	711.3	0.53	41.9	25.07	**78.8**
	Trichodorus spp.	63.15	27.9	100	27.3	602.1	0.5	31.5	18.8	69.3
	X.americanum	41.55	14.9	83.3	22.5	403.7	1.6	66.4	39.7	74.7
Tagetes spp.	*Helicotylenchus* spp.	34.5	19.1	83.3	18.7	308.9	0.3	10.8	7.5	45.4
	Tylenchorynchus spp.	44.6	26.2	100	22.7	460.5	0.5	25.4	17.6	66.5
	Trichodorus spp.	12.8	8.4	41.66	9.6	82.9	0.4	5.12	3.5	20.4
	X.insigne	10.6	8.3	49.9	13.1	117.5	1.9	28.5	19.8	41.2
	X.americanum	42.6	25.3	100	22.7	473.8	1.6	68.2	47.3	**96.5**
	Pratylenchus spp.	20.4	12.5	55.5	13.1	168.2	0.3	5.9	4.1	29.7
Zinnia spp.	*Helicotylenchus* spp.	59.1	30.6	91.6	28.2	561.3	0.4	23.6	13.2	72
	Trichodorus spp.	70.3	36.4	100	30.9	703	0.4	28.1	15.7	83.9
	X.insigne	43.4	19.2	83.3	25.6	309.2	2.2	95.5	53.5	**101.4**
	X.americanum	19.8	13.7	49.9	15.1	222.5	1.6	31.6	17.6	43.1

AD=Absolute density, RD=Relative density, AF=Absolute frequency, RF=Relative frequency, PV=Prominence value, G= Biomass, TG=Total biomass, RG=Relative biomass, IV=Importance value

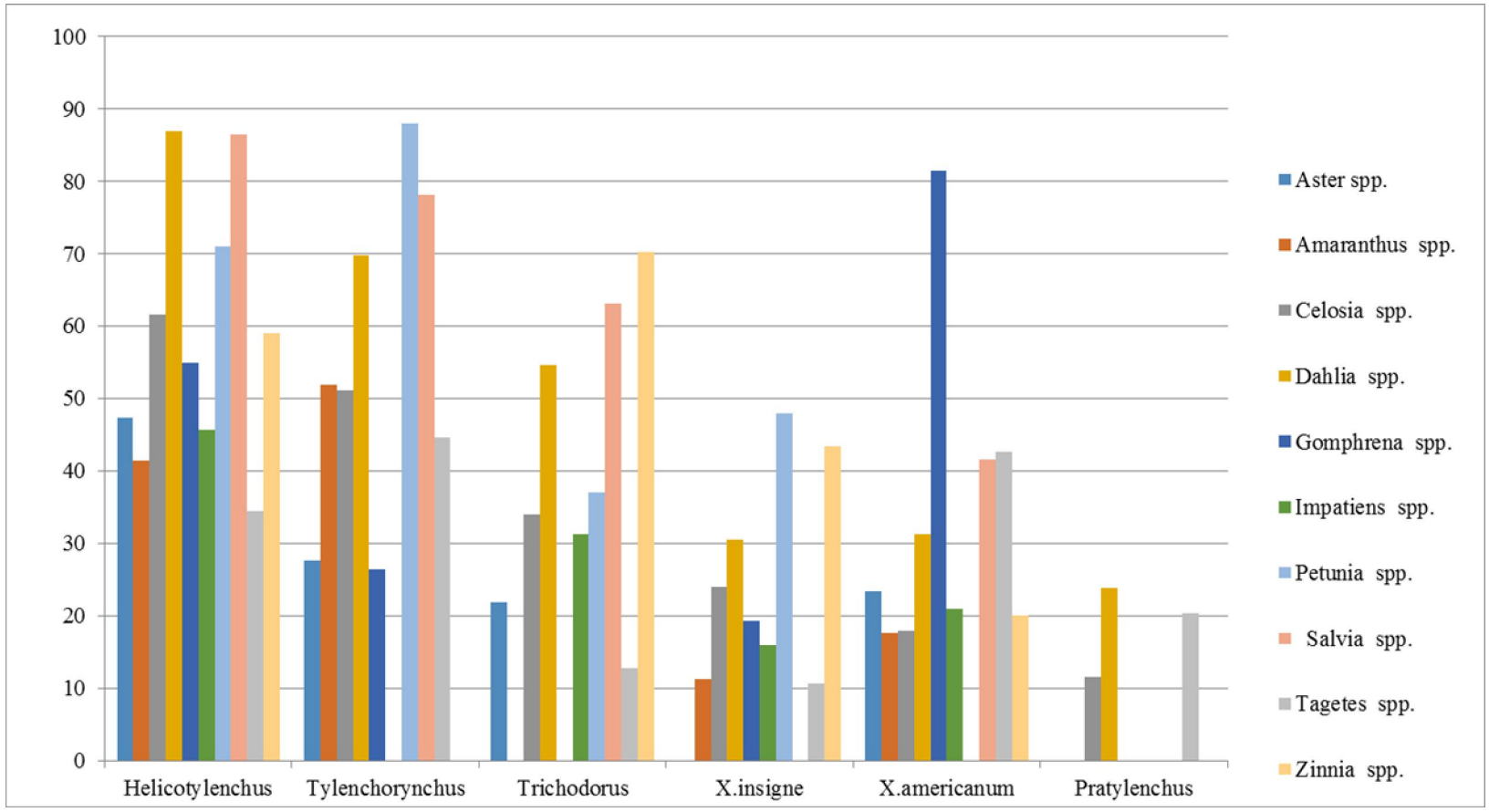


Fig. 5: Population density (per 250 cc soil) of pre-dominant plant parasitic nematodes on summer annuals in Mughal Gardens

Chapter-5

DISCUSSION

The results so gathered under the present study have been discussed below under appropriate headings:

5.1 Identification of pre-dominant plant parasitic nematodes associated with important summer annuals in Mughal Gardens of Srinagar, Kashmir

Nematodes are the most destructive and widespread agricultural pests inhibiting root growth and eventually overall plant development. They cause diverse damage in plants depending upon feeding habitat, most of them attack roots and different nematodes may attack the same plant. It is their large population not the isolated groups of individuals which harm the plant. Plant parasitic nematodes are responsible for serious injuries in roots and shoots of ornamental plants, consequently reducing their beauty and economic value. A large number of plant parasitic nematodes feed on the roots of ornamentals and other plants causing direct damage while many species of different plant parasitic nematodes have also been found responsible for transmission of serious viral diseases from one plant to another in various countries. These virus vector nematodes cause damage to many economically important crops both by direct feeding on the roots (Christie and Perry, 1951) and by vectoring plant diseases (Hewitt *et al*., 1958).

The most severe nematode problems occur where good host crops are grown too frequently for too long time on the same land. Gregarious feeding by various ectoparasitic and endoparasitic nematodes cause a decline in root growth by feeding on root tips. The aesthetic value of flowers and ornamental plants, their use in social events and gardening, overall satisfaction in working with them and high income generating power are attracting modern entrepreneurs to invest money in the floriculture industry. Jammu and Kashmir (J&K) region offers

suitable agro-climatic conditions, flower seed, dry flowers and bulb production for various flowers and that is why it was found necessary to reveal the status of plant parasitic nematodes on these ornamental flowers and open a new refreshed chapter for further studies in future.

In the present study six plant parasitic nematodes *viz*. *Helicotylenchus* spp., *Tylenchorhynchus* spp., *Trichodorus* spp., *Xiphinema insigne*, *X.americanum* and *Pratylenchus* spp., were isolated from the rhizosphere of summer annuals in Mughal Gardens (Chashma Shahi, Nishat, Pari Mahal, Shalimar). Among the major plant parasitic nematodes found on summer annuals during study, *Helicotylenchus* spp. was the widely occurring with high density in all the gardens followed by *Tylenchorhynchus* spp. The results are in conformity with the findings of Aasia Rashid, 2014 where she reported the same genera of nematodes on six ornamentals in Rajouri with highest population of *Helicotylenchus* spp. on *Tagetes* spp. Similar results were obtained by Jagirdar, S.A in 2005 where he listed the nematode species associated with carnation in Karnataka and reported the highest occurance of *Helicotylenchus* spp. Abbas and Waliuallah, 2010 also confirmed the same genera of nematodes with high population of *Helicotylenchus* spp. on gladiolus in Chashma Shahi, Kashmir. Salalia, Siddiqui and Parihar, 2002 also confirmed the presence of two new species of Xiphinema on perennial and ornamental crops in Udaipur. The above mentioned pre-dominant plant parasitic nematodes from the present study have already been reported in Kashmir. Among those nematodes, *Xiphinema americanum* has been reported by Lone and Zaki in 2013 from the rhizosphere of apple trees. Similarly, *Xiphinema insigne* has been reported by Lone and Zaki in 2014 from the neglected apple orchards in Baramulla, Kashmir.

Generally, the results of the present study are also in agreement with the findings of Manju and Subramanian, 2013 who reported the same genera of nematodes on gerbera in Tamil Nadu. The nematode genera Helicotylenchus, Pratylenchus, Tylenchorhynchus and Xiphinema as recovered from the Mughal

gardens of Srinagar, Kashmir in the present study have also been isolated from the ornamental plants in different parts of the world (Kafi, 1963; Krishnappa, 1980; Adekuncle, 2006; Mokbel, 2014; Sigariova and Karpliyk, 2015).

5.2 Population abundance and distribution of identified plant parasitic nematodes in Mughal Gardens.

The parameters, *viz.,* absolute frequency, relative frequency, absolute density, relative density, prominence value and biomass of different genera of nematodes were studied during the present investigation. One twenty soil samples of all the four gardens namely Chashma Shahi, Nishat, Pari Mahal and Shalimar revealed that among all the nematodes found during the present study, the maximum absolute density was recorded for *Helicotylenchus* spp. on *Aster* spp., *Celosia* spp., *Dahlia* spp., *Impatiens* spp. and *Salvia* spp. Similar results were obtained by Abbas and Waliullah, 2010; Rashid, 2014 and Aseffa, 2018. Similarly the relative density, absolute frequency and prominence value followed the same trend as that of absolute density in all the four gardens under study. These results are supported by the findings of Abbas and Waliullah, 2010 and Rashid, 2014.*Tylenchorhynchus* spp. was the second highly occurring nematode with high density, relative density, absolute frequency and prominence value on *Amaranthus* spp., *Petunia* spp. and *Tagetes* spp. Similar results were obtained by Rashid, 2008.

The maximum value of total biomass was showed by *Xiphinema americanum* on *Gomphrena* spp. followed by *Xiphinema insigne* on *Petunia* spp. The relative biomass followed the same trend as that of total biomass. The maximum importance value was showed by *X. americanum* on *Gomphrena* spp. followed by *Tylenchorynchus* spp. on *Amaranthus* spp. *Helicotylenchus* spp. had the highest importance value on *Aster* spp. The results of our study are in close conformity with the findings of Mushtaq (2020).

Chapter-6

SUMMARY AND CONCLUSION

Floriculture or flower farming has emerged as a profitable agri-business in J&K because of growing consciousness among the citizens to live in an environment friendly atmosphere. Floriculture involves cultivation of flowering and ornamental plants. These ornamentals include trees, shrubs, bulbous ornamentals, flowering annuals etc. Annuals are the starting point for any flower garden as well as a necessity in any well-planned garden. The various types of nematodes are encountered in the rhizosphere of summer annuals which not only reduces the production but also decreases the aesthetic value of these flowers. To study the incidence of different plant parasitic nematodes and their diversity is very much important in order to study their biodiversity and ecology with ornamental hosts and open a new chapter and challenge in the subject of Nematology.

The present study entitled as "Study of diversity of plant parasitic nematodes associated with important summer annuals under temperate conditions in Srinagar, Kashmir" was carried out to study the identification and community analysis of plant parasitic nematodes in Mughal Gardens of Srinagar, *viz.,* Chashma Shahi, Nishat, Pari Mahal and Shalimar. In all, six nematode species were isolated from the rhizosphere of summer annuals in all the four gardens under study *viz., Helicotylenchus* spp., *Tylenchorhynchus* sp., *Trichodorus* spp., *Xiphinema insigne*, *X.americanum* and *Pratylenchus* spp. where in only some of them showed greater strength in their population density, frequency etc. and were ascertained as most predominant plant parasitic nematodes in the above mentioned gardens. Community analysis of predominant plant parasitic nematodes in Mughal gardens of Srinagar on various parameters revealed that *Helicotylenchus* spp. showed highest mean absolute density on five annuals *viz Aster* spp., *Celosia* spp., *Dahlia* spp., *Impatiens* spp. and *Salvia* spp. in all the four gardens followed by *Tylenchorhynchus* spp. which showed the highest mean

absolute density on three annuals *viz., Amaranthus* spp., *Petunia* spp. and *Tagetes* spp. *Trichodorus* spp. and *X. americanum* showed the highest mean absolute density on *Zinnia* spp. and *Gomphrena* spp. respectively. The mean performance of parameters, *viz.,* relative frequency, relative density and prominence value also showed similar trend as that of the mean absolute density. The highest total biomass and relative biomass was found of *Xiphinema americanum* on *Gomphrena* spp. Moreover, the maximum importance value was also showed by *X. americanum* on *Gomphrena* spp. followed by *Tylenchorynchus* spp. on *Amaranthus* spp.

CONCLUSION

Five nematode genera of plant parasitic nematodes were found in all the four gardens *viz.,* Chashma Shahi, Nishat, Pari Mahal and Shalimar. The present community analysis revealed that *Helicotylenchus* spp., *Tylenchorhynchus* spp. and *Xiphinema americanum* were the most frequent and dominant species associated with the rhizosphere of summer annuals in Mughal gardens. Moreover, the study also revealed the wide host range of these nematode species with some nematodes being highly occuring on all the ten flower species like *Helicotylenchus* spp. followed by *Xiphinema* spp. The high population of these plant parasitic nematodes were encountered around the rhizosphere of these summer annuals and can be considered as a contributing factor in declining health and aesthetic value of these flowers.

Due to meager information, diversity among the species of nematodes could not be compared, however, it may be assumed that diversity varies considerably with habitat, area and the number of individuals. However, the nematode population of different sexes and stages, relative virulence of a particular species, its host specificity and tolerance level in host, needs to be investigated for assessing the role of these parameters in the management of plant parasitic nematodes. Also, *Xiphinema* spp. act as vectors of viruses and *Helicotylenchus* spp. are semi-endoparasitic responsible for lesion formation in

roots. Hence, their further study regarding infection of viral diseases and their management is the need of the hour.

In view of the above findings, monitoring of nematode populations in the nurseries and flower beds is required at regular intervals so that timely preventive management strategies may be adopted.

LITERATURE CITED

Abbas, A. and Waliullah, M. I. S. 2010. Prevelance of plant parasitic nematodes in *Gladiolus hortulans* L. in and Around Srinagar, Kashmir. *Indian Journal of Nematology* **40**(2): 179-183.

Adekunle, O. K., Kulshrestha, S., Prasad, R., Hallan, V., Raikhy, G., Verma, N., Ram, R., Kumar, S. and Zaidi, A. A. 2006. Plant parasitic and vector nematodes associated with Asiatic and Oriental hybrid lilies. *Bioresource technology* **97**(3): 364-371.

Ahuja, S. and Arora, J. S. 1980, Susceptibility of flowering annuals to root knot nematodes (Meloidogyne incognita). *Tropical Pest Management* **26**: 293-295.

Anonymous. 2005. Annual Report, National Horticulture Board. Jammu and Kashmir, 2007

Anwar, S. A., Gorsi, S., Anwar-ul-Haq, M., Rehman, T. and Yousuf, P. 1991. Plant parasitic nematodes of some fields, vegetable, fruit and ornamental crops. *Pakistan Journal of Agricultural Research* **29**: 233–249.

Arora, J. S. 1999. Introduction to ornamental horticulture. Kalyani Publishers, Ludhiana, India.

Aseffa, W. A. 2018. Community analysis of phytoparasitic nematodes associated with ornamental plants at Jimma University Agriculture Campus, Ethiopia. *Pakistan Journal of Nematology* **36**(1): 111-115

Askary, T. H., Waliuallah, M. I. S. and Gupta, S. 2012. Population fluctuation of plant parasitic nematodes associated with pome, stone and nut fruit nurseries. *Annals of Plant Protection Sciences* **20**(1): 265-267.

Audery, M. 1960. Root knot of Gomphrena. *Proceedings of the Indian Academy of Sciences* **53** : 318–324.

Baqri, Q. H. 1999. Diversity in plant and soil nematodes of West Bengal, India. An over view. Proceeding of the Indian National Science Academy. Part B, Reviews and Tracts. *Biological Sciences* **65**(1-2): 1-4.

Barsi, L. and Lamberti, F. 2004. Morphometrics of *Longidorus juvenilis* and first record of *L. aetnaeus* and *L. moesicus* (Nematoda: Dorylaimida) from Serbia. *Nematologia Mediterranea* **32**(1): 5-14.

Borgohain, N. 2016. Plant parasitic nematodes associated with some important commercial flowers. *Journal of Global Biosciences* **5**(8): 4541-4549.

Chandel, S. S., Khanna, A. S. and Khan, M. L. 1997. Faunistic studies on nematodes associated with Gladiolus. *Ann. Agri. Res.* **18**: 44-47.

Charchar, J. M., Eisenback, J. D. and Hirschmann, H. 1999. *Meloidogyne petuniae* n. sp. (Nemata: Meloidogynidae), a root-knot nematode parasitic on petunia in Brazil. *Journal of Nematology* **31**(1): 81.

Choudhury, B. N., Rahman, M. F. and Bora, A. 2004. Diversity of nematodes in four districts of Assam. *Indian Journal of Nematology* **34**(2): 222-224.

Christie, J. R. and Perry, V. G. 1951. Removing nematodes from soil. *Proceedings of Helminth. Society Washington* **18:** 106-108.

Cobb, N. A. 1918. Estimating the nema population of the soil with special reference to the sugar-beet and root-gall nemas, *Heterodera schachtii* Schmidt and *Heterodera radicicola*. *Agris* **1**: 48.

Cobb, N. A. 1913. New nematode genera found inhabiting fresh water and non-brackish soils. *Journal of Washington Academy of Sciences,* Washington **36(**4): 432-444.

Deimi, A. M., Chitambar, J. J. and Maafi, Z. T. 2008. Nematodes associated with flowering ornamental plants in Mahallat, Iran. *Nematologia Mediterranea* **36**: 2.

Dias-Arieira, C. R., Morita, D. A. S. and Machado, M. H. 2007. Nematodes associated with ornamental plants in a greenhouse from Paraná state, Brazil. *Nematologia Brasileira* **31**(1): 46-53.

Ei-Deen, N. A., Hadeer, D. Y., El-Ghamdi, A. A. and Samra, B. N. 2015. Evaluating the Pathogenicity of Nematodes Infecting Roses at Taif Governorate, KSA. *Research Journal of Pharmaceutical Biological and Chemical Sciences* **6**(2): 1562-156

Filipzev, I. N. 1936. On the classification of the Tylenchinae. *Proceedings of Helminthology Society of Washington* **3**: 80-82.

Gowda, B. T. 2005. A study on cultivation and marketing pattern of selected in Belghum district. Msc Thesis.University of Agricultural Sciences, Dharwad.

Hague, N.G.M, 1972. Economic Nematology. Academic Press, London.

Hewitt, W. B., Raski, D. J. and Goheen, A. C. 1958. Nematode vector of soil-borne fanleaf virus of grape vines. *Phytopathology* **48**: 586-595.

Hoestra, H. 1967. Specific apple replant disease: problems and prospects. *Meded Rijksfac Landb Wwt Gent* **32**: 427-432.

Hooper, D. J. 1970. Handling, fixing, staining and mounting nematodes. **In**: J.F. Southey (Ed). Laboratory methods for work with plant and soil nematodes. *Tech. Bull. Minist. Agric.Fish.Fd 2, (5th edition). London, H.M.S* pp. 39-54.

Hubin, O. I. 2013. Nematode diseases of flower and ornamental plants in the greenhouses and botanical gardens of Ukraine. Manuscript of the candidate of biological sciences Dissertation, Kyiv, 1–190 [In Ukrainian].

Jagirdar, S. A 2005. Studies on plant parasitic nematodes associated with polyhouse crops. M. sc thesis. Department of plant pathology, University of Agricultural Sciences, Dharwad.

Jitender, S. 2016. Population dynamics of plant parasitic nematodes associated with apple orchards in Himachal Pradesh (Doctoral dissertation).

Kafi, A., 1963. Plant parasitic nematodes in Pakistan. FAO Regional Office for Asia and the Far East.

Khan, M. L. and Verma, A. K. 2005. Occurrence of longidorid nematode species from the high altitude zone of Himachal Pradesh with description of *Paralongidorus neoformis sp*. n. *National Symposium on Recent Advances and Research Priorities in Indian Nematology*. IARI, New Delhi, December **63**: 9-10.

Khan, M. R. and Pal, A. P. 2001. Plant parasitic nematodes associated with tuberose (*Polianthes tuberosa* L.) in West Bengal. *Sci*. **9**(2): 357-359.

Khan, R. M. 2005. Root-knot Nematode Problem of Some Winter Ornamental Plants and Its Biomanagement. *Journal of Nematology* **37**(2): 198–206

Khan, R. M. and Reddy, P. P. 1991. Occurrence and distribution of potentially pathogenic endophytic nematodes associated with some ornamental, medicinal and aromatic crops. *Indian Phytopathology* **44**: 501-502.

Khanna, A. S. and Khan, M. L. 1990. Nematodes associated with some ornamental plants in India. *International Nematology Network Newsletter* **7**: 28-29.

Kim, J. I., Choi, D. R., Han, S. C. and Park, J. S. 1987, Survey on plant parasitic nematodes in fields growing ornamental plants and medical herbs. *Research Reports of the Rural Development Administration Plant Environment*. Agriculture Science Institute, Korea **29**: 124-129.

Kiryanova. E. S. and Krall, E. L. 1980. Plant parasitic nematode and their control (Book) Amerind publishing Co. **2**: 731.

Krishnappa, K., Prasad, K. S. K. and Reddy, B. M. R. 1980. A preliminary note on the plant parasitic nematodes associated with ornamental plants at Hebbal Campus of University of Agricultural Sciences Bangalore **9**(6): 101-103.

Kumar, K. K. and Das, A. K. 2019. Diversity and community analysis of plant parasitic nematodes associated with citrus at citrus research station, Tinsukia, Assam. *Journal of Entomology and Zoology Studies* **7**(3): 187-192.

Lone, G. M. and Zaki, F. A. 2013. Report of dagger nematode *Xiphinema americanum* (cobb, 1913) (dorylaimida: Longidoroidea) from rhizosphere of apple trees in Kashmir (India). *SKUAST Journal of Research* **15**(2): 137-140.

Lone, G. M. and Zaki, F. A. 2014. Report of *Xiphinema insigne* (Loos, 1949) and Longidorus elongatus (deMan, 1876 ; Thorne and Swanger, 1936 Dorylaimidae: Longidoroidea) from Rhizosphere of Neglected Apple Trees of Kashmir, India. *Indian Journal of Nematology* **44**(2): 232-237.

Lone, G. M., Zaki, F. A. and Anwar, A. 2018. Occurrence and Status of Virus Vector Nematodes in Apple Ecosystem of Kashmir, India. *Indian Journal of Nematology* **48**(1): 103-107.

Lone, G. M., Zaki, F. A. and Waliullah, M. I. S. 2012. Report of *Xiphinema index* Thorne and Allen, 1950 (Dorylaimida: Longidoroidea) associated with neglected apple orchards of Baramulla, Kashmir, India. *Indian Journal of Nematology* **42**(1): 71-74.

Lone, G.M. 2009. Biodiversity and ecology of some Adenophoreans (Dorylamida: Longidoridae) associated with apple in Baramullah, Kashmir. PHD thesis. Division of Entomology, SKUAST-K Wadora.

Loos, C. A. 1949. Notes on free-living and plant parasitic nematodes of Ceylon. No. 5. *Journal of Zoological Society of India* **1**: 23-29.

Luc, M., Sikora, R. A. and Bridge, J. 2005. Plant parasitic nematodes in subtropical and tropical agriculture. 2nd ed. Willingford: *CAB International* **12** : 467

Mackenzie, A. 1961. June. Root knot of Gomphrena globosa. **In**: *Proceedings of the Indian Academy of Sciences-Section B*. Springer India **53**(6): 318-324.

Mahdavian, E. S. and Jahanshahi, F. 2017. Identification, Distribution and Density Determination of Plant Parasitic Nematodes in Ornamental Plants of Mazandaran. *International Journal of New Technology and Research* **3**: 51-55

Manju, P. and Subramaniam, S. 2015. Survey of plant parasitic nematodes associated with gerbera in Tamil Nadu. *International Journal Of Science And Nature* **6**: 586-589

Maqbool, M. A., Hashmi, S. and Ghaffar, A. 1986. Eleven new hosts of root-knot nematodes and identification of physiological races in Pakistan. *Pakistan Journal of Nematology* **4**(1): 11-14.

McElory, F. D. 1972. Nematodes of tree fruits and small fruits. (In*) Economic Nematology* (Book). Academic *Proceedings of the Ohio State Horticultural Society* **125**: 91-94

Meressa, H. B *et al.* 2015. Descriptions of four new records of plant-parasitic nematode species from commercial cut-flowers in Ethiopia. *Nematoda* **2**: 2-3

Mokbel, A. A. 2014. Nematodes and their associated host plants cultivated in Jazan province, Southwest Saudi Arabia. *Egypt. J. Biol. (Zool)* **10:** 35-39

Musarrat, A. R., Firoza, K. and Shahina, F. 2006. Study of root-knot nematodes (*Meloidogyne* spp.) in NWFP and Sindh, Pakistan. *Pakistan Journal of Nematology (Pakistan)*.

Mushtaq, D. 2020. Diversity of plant parasitic nematodes in high density apple plantation of Kashmir. Msc thesis. Division of entomology, SKUAST-Kashmir. pp 54-60.

Nagesh, M. and Parvatha R. P. 1996. Management of *Meloidogyne incognita* on carnation and gerbera in commercial polyhouses. *Second International Crop Science* **3**: 17-24.

Nath, R. C., Sinha, B. C., Mukherjee, B. and Dasgupta, M. K. 2009. Community analysis and diversity of plant parasitic nematodes associated with litchi plantations in North Tripura District. *Pest Management in Horticultural Ecosystems* **15**(1): 51-59.

Nengroo, A. H., Bhat, G. M. and Khaki, A. R. 2016. Economic impact of Tourism in Jammu and Kashmir. *Indian Journal of Economics and Development* **4**: 3.

Nilambika, Sumangala, K. and Netravati 2018. Survey and distribution of plant parasitic nematodes on tuberose in four districts. *Journal of Pharmacognosy and Phytochemistry* **7**(2): 1622-1625.

Norton, D. C. 1978. Ecology of plant parasitic nematodes John Wiley and sons, Inc: New York USA pp. 263

Oliveira, C. M. G., Kubo, R. K., Antedomenico, S. R., Monteiro, A. R. and Inomoto, M. M. 2007. Occurrence of plant parasitic nematodes on ornamental plants in São Paulo and Minas Gerais states, Brazil. *Revista Brasileira de Horticultura Ornamental* **13**(2): 135-141.

Park, S., Khan, Z., Choi, Y. and Choi, B. 1998. Association and distribution of plant parasitic nematodes in peony (Paeonia lactiflora) fields of Korea. *International Journal of Nematology* **8**(1): 57-60.

Pathak, M. and Siddiqui, A. U. 1997. One new and five known species of *Tylenchorhynchus* Cobb, 1913 from ornamental crops in Udaipur region of Rajasthan. *Indian Journal of Nematology* **27**(1): 99-103.

Petit, R. and Crozzoli, R. 1995. Plant parasitic nematodes associated with ornamental crops in Venezuela. *Fitopathologia-Venezuelana* **8**: 41-44.

Raina, V., Nain, M. S., Sharma, R., Khajuria, S., Kumbhare, N. V. and Bakshi, M. 2017. Floriculture in Jammu and Kashmir: Performance, problems and prospects. *Journal of Pharmacognosy and Phytochemistry* pp. 287-293.

Rama, K. and Dasgupta, M. K. 2000. Population ecology and community structure of plant parasitic nematodes associated with ginger in West Bengal. *Indian Journal of Nematology* **28**(1): 10-14.

Rama, K. and Dasgupta, M.K., 2000. Population ecology and community structure of plant parasitic nematodes associated with coconut and arecanut in northern West Bengal. *Indian Journal of Nematology* ***30***: 175-182.

Randhawa, G. S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied Publishers, New delhi.

Rashid, A. 2008. Studies on the plant parasitic nematodes associated with some ornamental plants. M. Sc Thesis. Department of botany, Aligarh Muslim University.

Rashid, A., Azad, S. A. and Umar, F. 2014. Community analysis of plant parasitic nematodes associated with ornamental plants in Rajouri district (J&K), India. *International Journal of Current Microbiology and Applied Sciences* **3**(1): 194-197.

Sahu, R., Chandra, P. and Poddar, A. N. 2011. Community analysis of plant parasitic nematodes prevalent in vegetable crops in district Durgh of Chattisgarh, India. *Research journal of parasitology* **6**(2): 83-89

Salalia, R., Siddiqui, A. U. and Parihar, A. 2002. Two new species of Xiphinema Cobb associated with perennials in Udaipur with notes on a known associated species. *Indian Journal of Nematology* **32**: 92.

Sasser, J.N., 1987. A world perspective on nematology: the role of the society. *Vistas on Nematology* 7-14.

Sen, D., Chatterjee, A. and Manna, B. 2008. Population fluctuation of Helicotylenchus Steiner, 1945 in relation to soil temperature, moisture and

pH in guava orchard at South 24 Parganas, West Bengal, India. *Records of the Zoological Survey of India* **108**(2): 75-81.

Shahina, F. and Musarrat, A.R., 2006. Root-knot and reniform nematodes infecting some ornamental and medicinal plants in Pakistan. *Pakistan Journal of Nematology (Pakistan)* **8**: 56-60.

Shamashtabrezkhan, A. 2005, Studies on plant parasitic nematodes associated with polyhouse crops. M. Sc. (Agri.) Thesis. Univ. Agric. Sci., Dharwad pp. 48.

Sheikh, M. Q., Bhat, Z. A., Sidddique, M. A. A., Singh, K. P. and Saha, T. N. 2015. Present status and prospects of floriculture in Jammu and Kashmir. Indian Council of Agricultural Research Directorate of Floricultural Research, Pune **13**: 138.

Sigariova, D. D. and Karpliyk, V. G. 2015. Parasitic nematodes in flowering and ornamental plants: effect of parasites on the plants and response of the plants to the presence of nematodes. *Vestnik Zoologii* **49**(5): 427-432

Singh, R. and Kumar, U. 2013. Assessment of Nematode Distribution and Yield Losses in Vegetable Crops of Western Uttar Pradesh in India. *International Journal of Science and Research* **4**: 2812-2813.

Sodeuk, P., Khan, Z., Youngeoun, C. and Boosull, C. 1998. Association and distribution of plant parasitic nematodes in peony (Paeonia lactiflora) fields of Korea. *International Journal of Nematology* 8: 57-60

Steiner, G. 1945. *Helicotylenchus*, a new genus of plant parasitic nematodes and Its relationship to *Rotylenchus* Filipjev. *Proceedings of Helminthology Society of Wash*ington **12**: 34-38.

Sujata and Sharma, G. C. 2018. Status of phyto-parasitic nematodes in major fruits and vegetable crops of the tribal belt Kinnaur in Himachal Pradesh. *Journal of Entomology and Zoology Studies* **6**(2): 3069-3072.

Sundarababu, R. and Vadivelu, S. 1988. Pathogenic Meloidogyne spp. on tuberose. *Indian Journal of Nematology* **18**: 36-38.

Surega, R. and Ramakrishnan, S. 2017. Community analysis of plant parasitic nematodes in turmeric (*Curcuma longa* L.). *Journal of Entomology and Zoology Studies* **5**(4): 758-764

Tenete, R. C. 1996, Nematode problems of bulbs, with special reference to Ditylenchus dipsaci. *Nematropica* **26**: 91-99.

Yamamoto, E. and Toida, Y. 1995. Fauna of plant parasitic nematodes in temperate region of Japan. *JIRCAS* **2**: 43-48.

Zaki, F. A. and Mantoon, M, A. 2006. Plant parasitic nematodes associated with temperate fruit in Kashmir valley, India. *Pest Management and Economic Zoology* **2**: 97-101.

Zalpuri, L., Tara, J. S. and Singh, V. K. 2013. Plant and Soil Nematodes: Diversity and Interactions. *Global Journal of Biology, Agriculture and Health Sciences* **2**(2): 123-124.

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Faculty of Horticulture, Division of Entomology

CERTIFICATE

Certified that all the corrections/amendments as suggested by External Examiner Dr. Rajan Salalia, Sr Scientist, Nematology, Div. of PBG, SKUAST-Jammu during Viva-Voce examination held on 11-05-2021 have been incorporated in the manuscript entitled, **"Study of diversity of plant parasitic nematodes associated with important summer annuals under temperate conditions in Srinagar, Kashmir"** submitted by **Ms. Huzaifah Ashaq (Regd. No. MSH-2018-197).**

(Dr. Gh. Mohd. Lone)
Chairman
Advisory Committee