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Research Article

POPULATION DYNAMICS OF PLANT PARASITIC NEMATODES IN DISTRICT BAHAWALPUR

Iqra Mushtaq[1*], Qaiser Shakeel[1], Muhammad Naveed Aslam[1], Aqeel Ahmad Nawaz[1], Tanveer Ahmed[1], Muhammad Raheel[1]

[1]*Department of Plant Pathology, Faculty of Agriculture and Environment, The Islamia University of Bahawalpur, Pakistan.*

**Corresponding Authors: hafizaiqramushtaq@gmail.com*

Abstract

Plant-parasitic nematodes are among the most destructive soil-borne pests worldwide, causing substantial yield and economic losses in agricultural crops. They have a more influential effect in those areas where intensive systems of cropping are practiced. The subtropical climate and constant practice of vegetable farming in Pakistan favor the fast accumulation of nematodes, consequently root-knot nematodes (*Meloidogyne* spp.) have become a significant risk to vegetable production, particularly in Punjab. The aim of this study is the examination of the population, distribution, and pathogenicity of PPNs related to key vegetable plants in District Bahawalpur, Punjab, Pakistan. The systematic nematological survey was done in nine localities in which forty soil and root samples of eggplant, chilli, tomato, cucumber, and okra fields were carried out. Extraction and identification of nematodes were done under regular morphological and taxonomic methods such as permanent and temporary slide preparation. The host susceptibility was assessed using galling index and galling severity scales. Findings showed extensive nematode-infestation in all the localities surveyed with the levels of infection of between 50 and 86.67 with the highest prevalence occurring in Yazman. It was determined that there are six genera of invasive parasites of plants in this group of nematodes, but *Meloidogyne incognita* showed the most significant and destructive results, as it was found in 78 % of the samples *M. javanica* and *Criconema* spp. were also regularly occurring, whereas *Xiphinema*, *Helicotylenchus* and *Pratylenchus* spp. had irregular distribution patterns. The assessment of the pathogenicity showed that tomato and cucumber were the most affected, which severely rooted galled, and chilli was relatively less affected. The results suggest the serious menace of root-knot nematodes in the production of vegetables in Bahawalpur and the need to identify the species accurately and establish region-specific integrated approaches of managing the nematodes to minimize the loss of yield and assurance the production of the crop sustainably.

Keywords: *Plant parasitic nematodes, Crop sustainably, Survey, Vegetables.*

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1. INTRODUCTION

Plant-parasitic nematodes (PPNs) around the world have become one of the greatest biotic limiting factors to sustainable agriculture, resulting in losses to crops amounting to more than 173 billion annually (Ansari and Saleem, 2023). Of the variety of taxa in the Phylum Nematoda, *Tylenchida* and *Dorylidae* taxona are very common in ecological settings in the soil. Among them, the root-knot nematodes (RKN), or in more specific terms, the representatives of the genus *Meloidogyne*, are the most economically destructive agents, as they have a broad host range, and lead a sedentary endoparasitic lifestyle. These organisms infect vascular root tissues and cause the development of typical galls that interfere

with the movement of water and nutrients (Abd-Elgawad, 2021).

The problem of nematode infestations is a serious risk to food security and economic stability in the agricultural environment of Pakistan. The local climate in the country is subtropical, which is characterized by high rates of cropping patterns, thus allowing many PPN genera to thrive. *Meloidogyne incognita* is regarded as the most harmful species of nematodes which tend to damage vegetable plants within the country (Das *et al.*, 2024a). This issue is especially acute in the province of Punjab, where the usage of modern cultivation methods, including tunnel farming, implies quick changing planting. Such practices usually inhibit natural depletion of nematodes seasonally, and cause an increase in cumulative inoculum in the soil (Das *et al.*, 2024b). District Bahawalpur is a key vegetable growing region in the southern part of Punjab which suffers huge losses in production due to nematode feeding and consequent secondary infections. The uneven growth of plants, a notable degree of stunting, chlorosis, and stagnation of the root system, have often been found during field observations in the district. Such symptoms are frequently complemented by the insufficient number of feeder roots and brown necrotic lesions. To control these soil-borne pests, it is important that the taxonomic knowledge that is necessary to identify the specific organisms is accurate (Hussain and Mukhtar, 2019). Due to the high variability in density and frequency of nematodes across fields, the dynamics of local populations is necessary. Conventional diagnostic techniques such as the study of the female perineal pattern and the permanent slide making which is then subjected to morphological examination are still basic in distinguishing species-wise difference between prevalent regional pathogens such as *M. incognita* and *M. javanica* (Hussain and Mukhtar, 2019).

The study aimed to examine the population ecology of plant-parasite nematodes in the District Bahawalpur area in terms of their distribution among the important vegetable-hosts (tomato, eggplant, cucumber and okra). Through the measures of percentage of infections and galling levels in different localities. The research intends to present the background information which is needed to administer integrated methods of nematode control. It is important to reduce the population of the nematodes to the level where the products of the vegetable industry in this region would not be endangered by this economic factor.

2. MATERIALS AND METHODS

Survey and sample collection

To estimate the dynamics of the population of plant-parasitic nematodes, a systematic nematological survey was carried out in nine localities (Dera Bakha, 13 Solang, 33BC, Fattu Wali, IUB, Karachi Mor, Noorpur, Yazman, Zakhira) of District Bahawalpur in 2019. Forty field samples that included soil and root tissues were sampled in the rhizosphere of five major vegetable hosts, Eggplant (*Solanum melongena*), Chilies (*Capsicum annuum*), Tomato (*Lycopersicum esculentum*), Cucumber (*Cucumus sativus*) and Okra (*Abelmoschus escluntus*). The samples were placed in sterile polyethylene bags and transported to the Plant Pathology Laboratory, Department of Plant Pathology, The Islamia University of Bahawalpur (IUB), for further processing (Anwar *et al.*, 2013a).

Nematode extraction and identification

To determine plant-parasitic and free-living genera, nematodes were obtained on the soil and on root samples. Morphological and taxonomic forms of identification were done using the microscope (Hallmann and Subbotin, 2018).

Preparation techniques of slides

There were two sets of slides to be examined under the microscope in detail:

Temporary Slides: The freshly fixed specimens were placed on TAF. A drop of glycerol was put on a glass slide, and the specimen was placed down, and a coverslip was applied. The glycerol was wiped off excessively and the coverslip was sealed by using nail polish (Kimenju *et al.*, 2004).

Permanent Slides: A wax ring was prepared in the center of a slide made out of glass. The nematode was loaded into the drop of glycerin in the ring with the help of a hair-needle. A coverslip was put over the mount, and the slide was put on a moderately hot plate in order to ensure the permanent seal (Ryss, 2003).

Assessment of Pathogenicity

Nematode infection effects were measured under two standardized test scales:

Galling Index: A 0-5 scale was used with 0 meaning no galls and 5 meaning a severe case of over 100 galls per system.

Galling Severity: This was estimated on a scale of 1 9 with 1 signifying no galling and 9 signifying 76100 per cent of the root system being galled (Zhang *et al.*, 2006).

3. RESULTS

An extensive nematological survey was used to determine the population dynamics of vegetable crop-associated plant-parasitic nematodes (PPN) in District Bahawalpur at different localities. Fourty field samples (soil and roots) were utilized. These are the most important vegetable hosts to be covered in the survey; Eggplant (*Solanum melongena*), Chilies (*Capsicum annuum*), Tomato (*Lycopersicum esculentum*), Cucumber (*Cucumus sativus*) and Okra (*Abelmoschus esculentus*).

The results showed prevalence of nematode infestation with a large variation in the percentage of infection in the nine localities sampled. Infection was found to be highest in Yazman with a rate of 86.67 with 13 of 15 samples being infected. On the contrary, the minimum rates of infections were registered in 13 Solang (62.5%) and 33 BC (50%), Fattu Wali (50%) as shown in Table1.

Incidence and taxonomic distribution

Plant-parasitic nematodes 6 genera were identified and a range of free-living nematodes as shown in Table 2.

The nematological community survey discovered a rich community of plant-parasitic nematodes in sampled vegetable fields of District Bahawalpur. Root-knot nematodes *Meloidogyne* spp. and *Criconema spp*. were the most frequently occurring, as they occurred across nine localities. It was particularly found that *M. incognita* was the most dominant and destructive species, with 78 percent of the vegetable samples yielding it, and it was found in *M. javanica* in 6 %. The other genera had patchier patterns of distribution; *Xiphinema* spp. was common in 66% of the localities, but absent in 33 BC, Noorpur and Yazman. The frequency of *Helicotylenchus* spp. was found to be highest at six out of the nine sites with *Pratylenchus* spp. showing the lowest prevalence as it was found in one locality within 13 Solang, Fattu Wali, Noorpur, and Zakhira only. All these results underscore the existence of root-knot nematodes as a major menace to the production of vegetables in the region.

Host susceptibility to root-knot nematodes at District Bahawalpur was estimated using the standardized galling indices and severity scales and the severity was found to vary widely across vegetable crops. Tomato and cucumber were found out to be the most susceptible hosts, the most susceptible with maximum galling index of 5 or a total of 100 galls per root system and a galling severity of 8, 66-75 of which roots were affected. Eggplant and okra were moderately susceptible with both having a severity rating of 7 as a galling severity of 51-65% root galling. Comparatively, chilli had the least damage when compared to the surveyed crops, thus maintaining a galling index of 3 and severity rating of 6 as shown in Table 3.

Table:1 Prevalence of nematode infection across district Bahawalpur

Location	No. of samples	No. of infected samples	Infection percentage
Dera Bakha	12	9	75%
13 Solang	8	5	62.5%
33BC	6	3	50%
Fattu Wali	8	4	50%
IUB	10	6	60%
Karachi Mor	8	6	75%
Noorpur	4	3	75%
Yazman	15	13	86.67%
Zakhira	11	8	72.73%

Table 2: Identified plant parasitic nematodes

Location	***M. incognita***	***M.javanica***	***Criconema spp.***	***Xiphinema spp.***	***Helicotylenchus* spp.**	***Pratylenchus* spp.**	**Free living nematodes**
Dera Bakha	+	+	+	+	+	-	+
13 Solang	+	+	+	+	+	+	+
33BC	+	+	+	-	-	-	+
Fattu Wali	+	+	+	+	+	+	+
IUB	+	+	+	+	-	-	+
Karachi Mor	+	+	+	+	+	-	+
Noorpur	+	+	+	-	+	+	+
Yazman	+	+	+	+	+	-	+
Zakhira	+	+	+	+	-	+	+
+ =Present , - = Absent							

Table 3: Host pathogenicity and damage severity

Crop	**No.of galls**	**No. of Females**	**No. of egg mass**	**Galling Index***	**Galling Severity****
Egg plant	60	72	43	5	7
Chilli	47	63	28	3	6
Tomato	74	92	39	5	8
Cucumber	69	81	54	5	8
Okra	64	76	42	5	7
Galling Indices (0-5):0 =no galls, 1=1 or 2, 2=3-10, 3=11-30, 4= 31-100, 5=>100					
** galling Severity: 1= no galling 2=<5% galled, 3=6-10%, 4=11-18%, 5=19-25%, 6=26-50%, 7=51-65%, 8=66-75, and 9=76-100% roots galled					

4. DISCUSSION

A survey on vegetable fields in District Bahawalpur showed that plant-parasitic nematodes had a well-distributed and rich community, which indicates that they have an enormous effect on the production of vegetables in the region. The prevalence of root-knot nematodes *Meloidogyne* spp. and *Criconema* spp. is an indicator of the good adaptation of the taxa to the local to the subtropical climate and intensive cropping systems, which contribute to the rapid reproduction and settlement of nematodes (Anwar *et al.*, 2013b). Of the identified species, *Meloidogyne incognita* was the most prevalent and harmful, which supports earlier research, according to which it is the main nematode risk in vegetable crops in Punjab (Anjali, 2023). The fact that it leads an endoparasitic lifestyle and is capable of establishing permanent feeding sites in roots is why it causes severe galling, especially in tomato and cucumber, which had the highest galling indices and severity. This kind of root damage interferes with the transport of nutrients and water causing stunting, chlorosis and low productivity. In contrast, chilli was relatively resistant with a comparatively lower level of susceptibility suggesting that it may exhibit some level of partial tolerance or resistance mechanisms as a result of it having an inbuilt root system. The uneven population of other genera, including *Xiphinema*, *Helicotylenchus* and *Pratylenchus*, is due to the effects of local environmental factors, the history of cultivation, and the nature of soils on promoting nematode populations. Although not as devastating in their own right, these nematodes can be used in combination with secondary infections to worsen the damage caused to the root and, as a result, lead to cumulative yield losses (Khan *et al.*, 2017). These findings emphasize the importance of proper identification of the species and awareness of host specific vulnerability in managing nematodes. Morphological diagnostic methods, such as permanent and temporary slide preparations, continue playing a role in regional survey and offer essential background data used to inform put-together control plans (Bogale *et al.*, 2020). This paper demonstrates that root-knot nematodes, especially *M. incognita*, are the most widespread cause of vegetable crop destruction in Bahawalpur, and it is necessary to develop crop-specific, location-specific, and nematode-specific management measures.

5. FUTURE PERSPECTIVE

Molecular diagnostic tools need to be integrated into future research using the morphological identification to enhance the capability of detecting species of nematodes, especially when mixed populations are involved. The dynamics of nematode populations in various cropping systems would be monitored over a long duration, which would assist to establish the most important periods of intervention. Significant focus should be on the development and implementation of vegetable cultivar resistant to nematodes as a sustainable management tool. Moreover, there are integrated strategies involving crop rotation, organic amendments and biological agents of control and they are promising as possible alternatives to chemical nematicides and need to be tested at local field conditions to provide sustainable production of vegetables in southern Punjab.

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