

# ***Meloidogyne* spp. root-knot nematode distribution and population status in Autumn pulses in Rajasthan's zone IIIA**

## **Abstract**

A survey was conducted to determine the distribution and occurrence of root-knot nematode, *Meloidogyne* spp. and other plant parasitic nematodes associated with Autumn pulses in Zone IIIA of Rajasthan. A total of 387 soil and root samples were collected from 25 different localities of zone IIIA in Rajasthan. Among them *Meloidogyne* spp. was found highest in 354 samples with 91.47% absolute frequency, 40.16 absolute density and 3.84 prominence value. *Helicotylenchus* spp., *Pratylenchus* spp., *Hoplolaimus* spp. etc., were also reported in surveyed localities. During the survey mung bean plants were found diseased with *Cercospora* leaf spot and anthracnose.

## **Introduction**

The pulses form an integral part of the cropping system of farmers all over the country because these crops fit well in the crop rotation and occupy an important position in the human diet, due to being a good source of vegetable protein (17-43%) and a supplement to a cereal based diet. India is one of the largest producers and consumers of pulses in the world. Pulses account for around 20 percent of the area under food grain and contribute around 7-10 percent of the total food grain production in the country. Pigeon pea (tur or arhar), chickpea (gram), mung bean, urd (black gram), masur (lentil), pea and various types of beans are major pulses grown in India. Mung bean is an excellent source of low cost and high-quality protein" (Taylor *et al.*, 2005). The nutritional value in mung bean per 100 gram is protein (2.04g), fat (0.18g), carbohydrate (5.9g), dietary fiber (1.8g), sugar (4.13g), calcium (13mg), iron (0.92mg) and phosphorus (54mg). (USDA 2018). It is a source of high quality protein for human consumption and serves fodder or green manure. All the pulses have the ability to fix nitrogen by association with rhizobium at 58-109 kg/ha. (Singh and Singh 2011). The crop is believed to be a native of India and Central Asia, but is now widely grown in Southeast Asia, Africa, South America and Australia. In India, it is grown in almost

all parts of the country, such as, Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Uttar Pradesh, Andhra Pradesh, Gujarat, Tamil Nadu, Jharkhand, Odisha, Chhattisgarh, Telangana, Bihar and West Bengal.

Various factors have been recognized for the low yield of pulses, including its poor quality of seed, incidence of disease and pests including nematode and adverse climatic conditions. Among all the stages of the mung bean crop, right from germination to maturity, is attacked by a large spectrum of diseases caused by fungi, bacteria, viruses, and nematodes.

In India, root-knot nematode was first reported by Barber (1901) on tea roots from the Devala territory of Kerala state. In India- the root-knot disease caused by *M. incognita* and *M. javanica* on mung beans was first reported by Singh (1972). In Rajasthan, Arya (1957) reported root-knot nematode on tomato from Jodhpur.

The nematode problem may be highly destructive to the mung bean crop and is characterized by arial disease symptoms on the infected plant with suppressed growth and yield. The extent of damage caused by root-knot nematode invasion varies with the initial nematode density present in the soil, host, cultural conditions and weather parameters like temperature, moisture etc. *Meloidogyne javanica* may complete its biological cycle in about 30-34 days when soil temperatures range from 25–30°C (Joshi *et al.*, 2020). Location and region having differences in soil conditions and environmental variations may influence the infectivity and losses caused by root-knot nematodes in pulse crops, mainly in mung bean.

### 3. MATERIALS AND METHODS

#### I. Survey

A systematic survey was carried out to determine the percent occurrence and distribution of root-knot nematodes, *Meloidogyne* spp. and other plant parasitic nematodes in Autumn pulses from 25 localities in zone IIIA of Rajasthan. A total of 390 soil and root samples were collected from mung bean fields. Samples were collected randomly from fields using khurpi. Collected soil and root samples were processed in the and counted for the presence of a nematode population in 200 cc soil and 5 g roots. Calculate the occurrence, absolute frequency, absolute density, and prominence value with the help of the formula.

#### II. Soil Sampling

Soil samples were collected randomly from the rhizosphere of the plants with the help of khurpi from 4-5 places in each at a depth of 15-20 cm, homogenized, filled in a polythene bag, labeled, and tagged with supporting information, viz. date of sampling, locality, host plant. These samples were then tied with the rubber band brought to the laboratory and stored in a refrigerator at about 100 C. The samples were processed within a week.

### III. Processing of Samples:

Initially, 200 cc of soil from each sample was refined by using Cobb's decanting and sieving technique (Cobb's 1918), followed by Baermann's funnel technique (Christie and Perry, 1951). After 24-48 hours, suspension was drawn in a beaker from the funnel and kept for some hours to allow the nematode to settle down at the bottom. The supernatant liquid was gently removed to get a concentrated nematode population. The suspensions were made up to 100 ml, bubbled and only 5 ml was drawn with the help of a pipette and poured in a counting disc. An average of three times was taken and then multiples to total suspension counts exercise was taken. The root-knot nematode and other plant parasitic juveniles were counted under a stereoscopic binocular microscope.

### IV. Estimation of Root Population:

Infested roots were washed thoroughly and stained with 0.1 percent acid fuchsin lactophenol at 80 °C for 2-3 minutes (Mc Beth *et al.*, 1941). After a gentle wash in tap water, roots were kept in clear lactophenol for at least 24 hours, and then they were examined under a stereoscopic binocular microscope. After staining, the roots were teased out, and the number of root-knot nematodes and other plant parasitic nematodes was recorded under a stereoscopic binocular microscope.

#### Percent Occurrence of Plant Parasitic Nematodes:

The frequency of occurrence percentage of the plant parasitic nematode infection in each locality was calculated by the following formula:

$$(a) \text{ Absolute frequency} = \frac{\text{Number of samples containing a species}}{\text{Total no. of samples collected}} \times 100$$

$$(b) \text{ Absoluted} = \frac{\text{No.ofindividualsofaspeciesina sample}}{\text{Total no. of samples collected}} \times 100$$

ensity

volumeofsample

$$(c) \text{ Prominencevalue} = \frac{\text{Absolutedensity} \times \sqrt{\text{Absolutefrequency}}}{100}$$

### Occurrence of percentage disease index (PDI):

During August to September of the Autumn season 2022-23, surveys on *Cercospora* leaf spot disease and anthracnose of mung bean were carried out in Zone IIIA of Rajasthan. Five plots were taken to indicate *Cercospora* leaf spot affected plants. In each plot, two spots of one-meter square quadrant were taken at random and each spot having diseased as well as healthy plants was recorded. Observations will be recorded according to the 12 grade scale. The percent disease index will be determined according to Horsfall and Barratt (1945).

List 1 : Occurrence of percentage disease index

Scale	Frequency
1	0%
2	0-3%
3	3-6%
4	6-12%
5	12-25%
6	25-50%
7	50-75%
8	75-87%
9	87-94%
10	94-97%
11	97-100%
12	100%

$$\text{Percent Disease Index (PDI)} = \frac{\text{Sum of all disease ratings}}{\text{Total number of ratings} \times \text{Maximum disease grade}} \times 100$$

## 4. Result and discussion

## A. Occurrence of nematode associated with mung bean in zone IIIA of Rajasthan

A study was carried out to determine the distribution and occurrence of root-knot nematodes, *Meloidogyne* spp., and other plant parasitic nematodes associated with Autumn pulses in Zone IIIA of Rajasthan. A total of 387 soil and root samples were collected from 25 different localities of zone IIIA of Rajasthan in Autumn season 2022-23 from August to September months. The samples were processed by using Cobb's decanting and sieving technique, followed by Baermann's funnel assembly. The extracted nematodes were examined under a stereoscopic binocular microscope. Observations on the number of root-knot nematodes, *Meloidogyne* spp., and other phytonematodes in 200 cc soil were taken and described in Table 1.

Data presented in table 1 showed that out of 387 samples, *Meloidogyne* spp. was found highest in 354 samples with 91.47% absolute frequency, 40.16 absolute density and 3.84 prominence value.

**Table 1: Percent occurrence of root-knot nematode and other phyto-nematodes associated with mung bean in Zone IIIA of Rajasthan.**

No.	Nematode spp.	Total Samples Collected	Samples Containing nematode spp.	Absolute frequency	No. of individuals of a spp.	Absolute Density	Prominence Value
1.	<i>Meloidogyne</i> spp.	387	354	91.47	29145	40.16	3.84
2.	<i>Helicotylenchus</i> spp.		197	50.90	495	1.22	0.08
3.	<i>Pratylenchus</i> spp.		178	45.99	934	2.55	0.17
4.	<i>Hoplolaimus</i> spp.		163	42.11	254	0.76	0.04

The results recorded during the survey showed that mung bean is susceptible to the attack of root-knot nematodes. The results showed that the 100% infection of root-knot nematode was recorded in 10 localities, i.e., Sanjhariya, Fatehpura, Begus, Nimeda, Chomu, Akhaipura, Lalsot, Dungarpur, Mandawar and Jobner.

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**Table 2: Distribution and occurrence of root-knot nematode, *Meloidogyne javanica* and other plant parasitic nematodes Zone IIIA of Rajasthan.**

Locality	Nematode Genera	No. of Samples	Samples Con. Nema. Spp.	Absolute Freq.	No. of Ind. Spp./200 CC soil	no. of ind. Spp./5g roots	Absolute den.	PV
<b>Sanjhariya</b>	<i>Meloidogyne</i>	21	21	100	867	432.00	30.17	3.02
	<i>Helicotylenchus</i>	21	6	28.57	35	432.00	0.83	0.04
	<i>Pratylenchus</i>	21	9	42.86	27	19.00	1.07	0.07
	<i>Hoplolaimus</i>	21	7	33.33	17	0.00	0.40	0.02
<b>Fatehpura</b>	<i>Meloidogyne</i>	16	16	100.00	811	447.00	25.34	2.53
	<i>Helicotylenchus</i>	16	12	75.00	45	0.00	1.41	0.12
	<i>Pratylenchus</i>	16	9	56.25	28	22.00	0.88	0.06
	<i>Hoplolaimus</i>	16	10	62.50	23	0.00	0.72	0.06
<b>Begus</b>	<i>Meloidogyne</i>	20	20	100.00	922	576.00	23.05	2.30
	<i>Helicotylenchus</i>	20	10	50.00	26	0.00	0.65	0.04
	<i>Pratylenchus</i>	20	8	40.00	18	14.00	0.45	0.03
	<i>Hoplolaimus</i>	20	11	55.00	40	0.00	1.00	0.07
<b>Bobas</b>	<i>Meloidogyne</i>	18	17	94.44	890	512.00	24.72	2.40
	<i>Helicotylenchus</i>	18	8	44.44	16	0.00	0.44	0.03
	<i>Pratylenchus</i>	18	10	55.56	24	17.00	0.67	0.05
	<i>Hoplolaimus</i>	18	6	33.33	14	0.00	0.39	0.02
<b>Bassi Jhajhra</b>	<i>Meloidogyne</i>	12	10	83.33	790	358.00	32.92	3.00
	<i>Helicotylenchus</i>	12	4	33.33	25	0.00	1.04	0.06
	<i>Pratylenchus</i>	12	7	58.33	30	16.00	1.25	0.09
	<i>Hoplolaimus</i>	12	5	41.67	11	0.00	0.46	0.03
<b>Keshyawala</b>	<i>Meloidogyne</i>	15	14	93.33	815	350.00	27.17	2.62
	<i>Helicotylenchus</i>	15	9	60.00	13	0.00	0.43	0.03

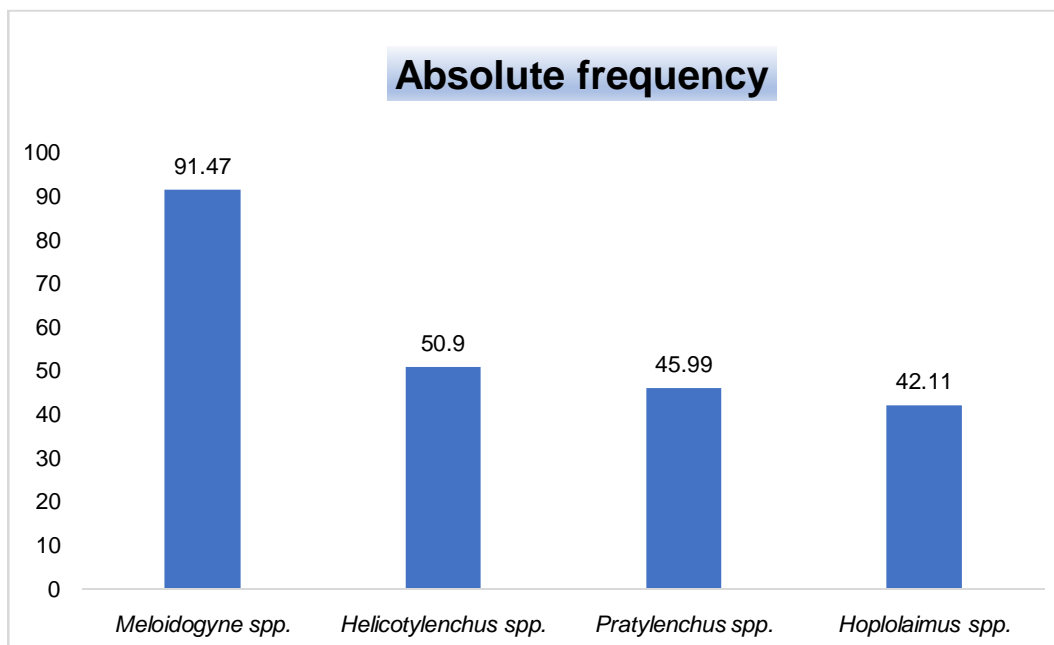
	<i>Pratylenchus</i>	15	7	46.67	23	26.00	0.77	0.05
	<i>Hoplolaimus</i>	15	6	40.00	9	0.00	0.30	0.02
<b>Nimeda</b>	<i>Meloidogyne</i>	14	14	100.00	788	425.00	28.14	2.81
	<i>Helicotylenchus</i>	14	8	57.14	11	0.00	0.39	0.03
	<i>Pratylenchus</i>	14	6	42.86	15	32.00	0.54	0.03
	<i>Hoplolaimus</i>	14	4	28.57	6	0.00	0.21	0.01
<b>Mundiya Ramsar</b>	<i>Meloidogyne</i>	16	15	93.75	857	466.00	26.78	2.59
	<i>Helicotylenchus</i>	16	7	43.75	14	0.00	0.44	0.03
	<i>Pratylenchus</i>	16	5	31.25	21	14.00	0.66	0.04
	<i>Hoplolaimus</i>	16	9	56.25	11	0.00	0.34	0.02
<b>Phagi</b>	<i>Meloidogyne</i>	22	20	90.91	812	410.00	18.45	1.76
	<i>Helicotylenchus</i>	22	10	45.45	15	0.00	0.34	0.02
	<i>Pratylenchus</i>	22	5	22.73	3	9.00	0.07	0.00
	<i>Hoplolaimus</i>	22	4	18.18	7	0.00	0.16	0.00
<b>Doobli</b>	<i>Meloidogyne</i>	13	12	92.31	618	345.00	23.77	2.28
	<i>Helicotylenchus</i>	13	5	38.46	14	0.00	0.54	0.03
	<i>Pratylenchus</i>	13	8	61.54	6	18.00	0.23	0.01
	<i>Hoplolaimus</i>	13	4	30.77	2	0.00	0.08	0.00
<b>Chomu</b>	<i>Meloidogyne</i>	18	18	100.00	847	457.00	23.53	2.35
	<i>Helicotylenchus</i>	18	11	61.11	8	0.00	0.22	0.01
	<i>Pratylenchus</i>	18	13	72.22	14	12.00	0.39	0.03
	<i>Hoplolaimus</i>	18	9	50.00	6	0.00	0.17	0.01
<b>Bassi</b>	<i>Meloidogyne</i>	19	18	94.74	884	568.00	23.26	2.26
	<i>Helicotylenchus</i>	19	11	57.89	12	0.00	0.32	0.02
	<i>Pratylenchus</i>	19	9	47.37	27	39.00	0.71	0.04

	<i>Hoplolaimus</i>	19	4	21.05	13	0.00	0.34	0.01
<b>Siya ka Was</b>	<i>Meloidogyne</i>	15	14	93.33	687	356.00	22.90	2.21
	<i>Helicotylenchus</i>	15	8	53.33	22	0.00	0.73	0.05
	<i>Pratylenchus</i>	15	12	80.00	16	38.00	0.53	0.04
	<i>Hoplolaimus</i>	15	10	66.67	9	0.00	0.30	0.02
<b>Akhaipura</b>	<i>Meloidogyne</i>	16	16	100.00	786	467.00	24.56	2.45
	<i>Helicotylenchus</i>	16	10	62.50	26	0.00	0.81	0.06
	<i>Pratylenchus</i>	16	5	31.25	15	28.00	0.47	0.02
	<i>Hoplolaimus</i>	16	9	56.25	5	0.00	0.16	0.01
<b>Charanwas</b>	<i>Meloidogyne</i>	14	12	85.71	766	348.00	27.36	2.53
	<i>Helicotylenchus</i>	14	7	50.00	21	0.00	0.75	0.05
	<i>Pratylenchus</i>	14	9	64.29	22	32.00	0.79	0.06
	<i>Hoplolaimus</i>	14	6	42.86	5	0.00	0.18	0.01
<b>Malpura</b>	<i>Meloidogyne</i>	10	4	40.00	486	208.00	24.30	1.53
	<i>Helicotylenchus</i>	10	3	30.00	21	0.00	1.05	0.05
	<i>Pratylenchus</i>	10	2	20.00	5	14.00	0.25	0.01
	<i>Hoplolaimus</i>	10	1	10.00	2	0.00	0.10	0.00
<b>Diggi</b>	<i>Meloidogyne</i>	10	3	30.00	360	150.00	18.00	0.98
	<i>Helicotylenchus</i>	10	2	20.00	11	0.00	0.55	0.02
	<i>Pratylenchus</i>	10	2	20.00	8	20.00	0.40	0.02
	<i>Hoplolaimus</i>	10	1	10.00	5	0.00	0.25	0.01
<b>Avikanagar</b>	<i>Meloidogyne</i>	14	9	64.29	634	389.00	22.64	1.81
	<i>Helicotylenchus</i>	14	7	50.00	16	0.00	0.57	0.04
	<i>Pratylenchus</i>	14	6	42.86	14	26.00	0.50	0.03
	<i>Hoplolaimus</i>	14	5	35.71	2	0.00	0.07	0.00

<b>Lalsot</b>	<i>Meloidogyne</i>	16	16	100.00	753	345.00	23.53	2.35
	<i>Helicotylenchus</i>	16	8	50.00	14	0.00	0.44	0.03
	<i>Pratylenchus</i>	16	6	37.50	11	5.00	0.34	0.02
	<i>Hoplolaimus</i>	16	9	56.25	9	0.00	0.28	0.02
<b>Ramgarh – Pacchwara</b>	<i>Meloidogyne</i>	12	11	91.67	588	298.00	24.50	2.34
	<i>Helicotylenchus</i>	12	9	75.00	13	0.00	0.54	0.05
	<i>Pratylenchus</i>	12	7	58.33	9	4.00	0.38	0.03
	<i>Hoplolaimus</i>	12	8	66.67	3	0.00	0.13	0.01
<b>Baswa</b>	<i>Meloidogyne</i>	14	13	92.86	754	467.00	26.93	2.59
	<i>Helicotylenchus</i>	14	8	57.14	30	0.00	1.07	0.08
	<i>Pratylenchus</i>	14	6	42.86	5	24.00	0.18	0.01
	<i>Hoplolaimus</i>	14	8	57.14	11	0.00	0.39	0.03
<b>Dungarpur</b>	<i>Meloidogyne</i>	18	18	100.00	879	516.00	24.42	2.44
	<i>Helicotylenchus</i>	18	6	33.33	17	0.00	0.47	0.03
	<i>Pratylenchus</i>	18	10	55.56	25	13.00	0.69	0.05
	<i>Hoplolaimus</i>	18	13	72.22	13	0.00	0.36	0.03
<b>Mandawar</b>	<i>Meloidogyne</i>	11	11	100.00	689	300.00	31.32	3.13
	<i>Helicotylenchus</i>	11	7	63.64	23	0.00	1.05	0.08
	<i>Pratylenchus</i>	11	4	36.36	19	30.00	0.86	0.05
	<i>Hoplolaimus</i>	11	2	18.18	3	0.00	0.14	0.00
<b>Jobner</b>	<i>Meloidogyne</i>	16	16	100.00	789	466.00	24.66	2.46
	<i>Helicotylenchus</i>	16	11	68.75	21	0.00	0.66	0.05
	<i>Pratylenchus</i>	16	7	43.75	13	23.00	0.41	0.03
	<i>Hoplolaimus</i>	16	3	18.75	15	0.00	0.47	0.02
<b>Durgapura</b>	<i>Meloidogyne</i>	17	16	94.12	851	578.00	25.03	2.43

	<i>Helicotylenchus</i>	17	10	58.82	26	0.00	0.76	0.06
	<i>Pratylenchus</i>	17	6	35.29	18	32.00	0.53	0.03
	<i>Hoplolaimus</i>	17	9	52.94	10	0.00	0.29	0.02

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**Fig. 1: Absolute frequency of root-knot nematodes and other plant parasite nematodes**

**B. Occurrence of disease associated with mung bean other than nematode disease in zone IIIA of Rajasthan**

Total 25 mung bean-growing villages surveyed zone IIIA of Rajasthan to record the occurrence of different diseases during the Autumn season of 2022. The villages were surveyed from the flowering and pod-forming stages of the mung bean crop. The data indicated in Table 3 revealed that the Cercospora leaf spot intensity ranged from 0.00 to 37.71 percent with an average of 13.64 percent during August to September 2022. While anthracnose intensity ranged from 0.00 to 30.02 percent with an average of 11.00 percent. The maximum Cercospora leaf spot intensity was observed at Diggi (37.71%), followed by Phagi (29.33%), Avikanagar (25.31%), Siyaka Was (21.65%), and Malpura (21.02%). Whereas, maximum anthracnose intensity in mung bean was found in Malpura (30.32%), followed by Diggi (29.66%) and Avikanagar (23.07%).

**Table: 3 Per cent occurrence of Cercospora leaf spot and Anthracnose disease associated with mung bean in Zone IIIA of Rajasthan.**

S.N.	District	Village	Cercospora leaf spot PDI (%)	Anthracnose PDI (%)
1.	Jaipur	Sanjhariya	10.02	8.26
2.	Jaipur	Fatehpura	16.50	9.02

3.	Jaipur	Begus	10.09	6.32
4.	Jaipur	Bobas	11.26	10.62
5.	Jaipur	Bassi Jhajhra	9.36	10.32
6.	Jaipur	Keshyawalya	7.10	6.01
7.	Jaipur	Nimeda	22.23	17.52
8.	Jaipur	Mundiya Ramsar	19.56	12.32
9.	Jaipur	Phagi	29.33	15.11
10.	Jaipur	Doobli	1.02	0.00
11.	Jaipur	Chomu	0.00	0.00
12.	Jaipur	Bassi	10.32	10.22
13.	Jaipur	Siya Ka Was	21.65	11.32
14.	Jaipur	Akhaipura	0.00	0.00
15.	Jaipur	Charanwas	10.03	9.01
16.	Tonk	Malpura	21.02	30.32
17.	Tonk	Diggi	37.71	29.66
18.	Tonk	Avikanagar	25.31	23.07
19.	Dausa	Lalsot	19.35	11.74
20.	Dausa	Ramgarh Pacchwara	5.02	6.1
21.	Dausa	Baswa	8.36	9.15
22.	Dausa	Dungarpur	10.02	2.81
23.	Dausa	Mandawar	12.31	10.37
24.	Jaipur	Jobner	5.01	8.06
25.	Jaipur	Durgapura	18.6	17.68
Average			13.64	11.00

The results of the present investigation were similar to those of Mishra and Chakrabarti (2001), who reported the association of root-knot nematodes, cyst nematodes, lesion nematodes, reniform nematodes, and various ectoparasitic nematode groups with all the pulse crops in pulse-producing areas of India. Olowe (2004) surveyed cowpea areas in Nigeria and showed that *Meloidogyne incognita* (51.8%) was the most prevalent nematode, followed by *Meloidogyne javanica* (44.1%) and *Meloidogyne arenaria* (4.1%), respectively. Amponsah *et al.* (2008) investigated the distribution of plant parasitic nematodes associated with peanut, cowpea and soybean in northern Ghana. Ten genera of plant parasitic nematodes were encountered in the three sites and host crops. These were *Helicotylenchus*, *Heterodera*, *Hoplolaimus*, *Longidorus*, *Meloidogyne*, *Pratylenchus*, *Rotylenchus*, *Scutellonema*,

*Tylenchorhynchus* and *Xiphinema*. Soil and root samples of cowpea growing areas from Churu, Jhunjhunu, Udaipur, Rajsamand and Chittorgarh districts of Rajasthan showed high prominence values of *Meloidogyne* and *Rotylenchulus reniformis* and *Tylenchorhynchus* spp. (Kumar *et al.*, 2010). Whereas, thirteen nematode genera (*Hoplolaimus*, *Tylenchorhynchus*, *Helicotylenchus*, *Tylenchus*, *Heterodera cajani*, *Pratylenchus*, *Basiria*, *Aphelenchus*, *Meloidogyne*, *Filenchus*, *Boleodorus*, *Rotylenchulus* and *Scutellonema*) are associated with pigeon pea from the Bundelkhand region of Uttar Pradesh (India) (Singh, 2015). However, infection of root-knot nematodes in tomatoes showed in all surveyed localities in and around the Sanganer Tehsils, Jaipur (Rajasthan) (Indoulia *et al.*, 2020). Manandhar *et al.* (2023) collected 211 soil samples in different crop fields; among them, 137 samples were diagnosed for different plant parasitic nematodes (*Meloidogyne*, *Helicotylenchus*, *Pratylenchus*, *Tylenchus*, *Tylenchorhynchus*, *Hoplolaimus*, *Belonolaimus*, *Criconemoides*, *Aphelenchoides*, *Hirschmanniella*, *Longidorus* and *Rotylenchulus*). In the present study also, root-knot nematode (*Meloidogyne* spp.) was found to be the prominent economically important plant parasitic nematode genera above the economic threshold level affecting mung bean, around zone IIIA of Rajasthan. This might be due to favorable environmental conditions of this area, availability of light soil, host suitability, sowing time of crop, *etc.*

## CONCLUSION

In the present study, root-knot nematode (*Meloidogyne javanica*) was found to be the only prominent economically important plant parasitic nematode genera and polyphagous nature. A survey showed that pulses is susceptible to the attack of root-knot nematode. The root-knot nematodes, *Meloidogyne* spp., is a major key pest in Rajasthan. Root-knot nematode *Meloidogyne javanica* is a major nematode pest in an Autumn pulse in zone IIIA of Rajasthan. During the survey, mung bean plants were also diseased with *Cercospora* leaf spot and anthracnose.

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