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Status of root-knot nematode (*Meloidogyne* species) disease in vegetable crops of some districts of central plain region of Chhattisgarh State, India

Surendra Kumar Gautam*, Gamini Sahu, Bhumesh Kumar Verma and Aditi Niyogi Poddar

Parasitology Laboratory, School of Life Sciences, Pandit Ravishankar Shukla University, Raipur-492010, Chhattisgarh, India.

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The root-knot nematodes (*Meloidogyne* species) are economically important pathogens, especially infesting vegetable crops. In the tropics and subtropics, *Meloidogyne incognita* causes an estimated yield loss of 5 to 43% in vegetable crops. In the present study, root-knot nematode disease was surveyed in various vegetable crops in the central plain region of Chhattisgarh State. Roots and rhizosphere soil samples were collected from 44 farmlands representing five districts of Chhattisgarh during mid cropping season. Nematodes were extracted by Cobb's sieving and decanting method, followed by modified Baermann's funnel technique. Out of 44 samples, 24 showed the root-knot nematodes infection with an overall incidence of 54.54%. The percent incidences of disease ranged between 30 and 80% in five districts. Out of 13 species of vegetable crops surveyed, nine were observed to be infected. The most frequently occurring species was *Meloidogyne incognita* (63.33%), followed by *Meloidogyne arenaria* (20%) and *Meloidogyne javanica* (16.67%). Maximum frequency was observed in *Lageneria siceraria* (100%), and least was *Musa paradisiaca*, *Daucus carota* and *Amaranthus tristis* (50%). The mean population density of 2nd stage nematodes ranged between 766 and 9076 nematodes/200 cc soil and 10 g roots in samples.

Key words: Root-knot nematode, survey, *Meloidogyne* spp., incidence, frequency, Chhattisgarh.

INTRODUCTION

The state of Chhattisgarh is situated between 17-23.7°N latitude and 80.40-83.38°E longitude in the central eastern part of India with a population of more than 20 million and total geographical area of 136.03 thousand sq. km. It is divided into three agro-ecological regions on the basis of topography; they are the Northern Hills, the Central Plains and the Bastar Plateau. The central plain also known as Chhattisgarh plain includes the districts of

Raipur (capital), Mahasamund, Dhamtari, Durg, Rajnandgaon, Kabirdham, Bilaspur, Korba, Janjgir and a part of Kanker (Narharpur and Kanker block) along with a part of Raigarh. Its richness in biotic and abiotic diversities as well as socio-economic conditions, favor the cultivation of various horticultural crops like vegetables, temperate, tropical and high elevation fruits. In spite of being known as the rice bowl of the country its

*Corresponding author. E-mail: gautam1436@gmail.com.

different soil types support vegetable cultivation. Chhattisgarh stands in 15th position in vegetable cultivation for the year 2008-2009 in India (Health Vision Research, 2009-10).

The root-knot nematodes (*Meloidogyne* spp.) are one of the most economically important plant pathogens especially in vegetable crops (Kalaiarasan, 2009), causing an estimated yield loss which varies from 5 to 43% (Sasser, 1979). The genus *Meloidogyne* attacks nearly every crop and has been reported to cause an annual loss of Rs. 547.5 million in Cucurbits (Jain et al., 2007; Chandra et al., 2010). There are three common species: *Meloidogyne incognita*, *Meloidogyne javanica* and *Meloidogyne arenaria*, among which *M. incognita* is widespread in the tropics and subtropics (Sasser, 1979).

Some preliminary works have been documented on the prevalence and community analysis of root-knot nematode infections in vegetable crops in some districts of the state of Chhattisgarh (Sao et al., 2008; Sahu et al., 2011). Occurrences of some plant parasitic nematodes, such as, *Aphelenchoides besseyii*, *Rotylenchulus reniformis*, *Radopholus similis*, *M. incognita* and *Rotylenchulus reniformis* are also reported (Khan et al., 2010). In this area, farmers bear a loss of productivity in vegetable crops due to lack of knowledge concerning these pests. However, no work has been documented on the incidence of the major *Meloidogyne* spp. in the districts of the central plains. The present study comprises of a survey of root-knot nematode diseases prevalent in various vegetable crops of the central plain region of Chhattisgarh state.

MATERIALS AND METHODS

A field survey of various villages belonging to the five districts of central plains of Chhattisgarh was conducted during September-February, 2011-2012 and 2012-2013 to determine the root-knot nematodes (*Meloidogyne* spp.) associated with various vegetable crops. Diseased fields were selected on the basis of above ground symptoms of the crops such as, wilting, slow growth, stunting and yellowing of leaves. Soil and root samples were collected by digging from a depth of 10-15 cm at the rate of one unit sample per acre crop area. Each unit sample was a composite of 20 cores obtained from four corners and centre of the field. Root/soil sub samples (prepared from the unit samples) were stored in polythene bags and kept at 4°C in a refrigerator for not more than seven days. In all, 44 soils and root samples were collected during mid cropping season.

Extraction of the nematodes was done by Cobb's sieving and decanting method followed by modified Baermann's funnel technique (Goodey, 1957; Southey, 1985) and the nematode suspensions collected. Infected roots were stained in Lacto phenol acid fuchsin (Himedia, India) and observed for the presence of nematodes. Species identification (Eisenback et al., 1981) was done by preparation of perineal sections of the females after dissecting out from the galled roots observed under Leica compound microscope with camera attachment. The estimation of nematode population per 10 g root sample and 200 cc soil sample was done in a multi-chambered counting dish under a stereoscopic binocular microscope (ZEISS, STEMI 2000C) and the incidence, occurrence and frequency was calculated using the formulae

(Norton, 1978):

$$\text{Disease incidence} = \frac{\text{Number of sample with root-knot nematodes infection}}{\text{Total number of sample surveyed}} \times 100$$

$$\% \text{ Occurrence of species} = \frac{\text{Number of sample with a species}}{\text{Total no. of samples observed}} \times 100$$

$$\text{Absolute frequency} = \frac{\text{No. of sample containing a species}}{\text{No. of sample collected}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of occurrence of species}}{\text{Sum of frequency of all samples}} \times 100$$

RESULTS

Incidence and occurrence of root-knot nematode disease (district wise)

In all, 44 samples belonging to 19 farmlands and 13 different vegetable crop species were collected during survey. Out of these, only nine crop species exhibited the presence of the root-knot nematodes. District wise variations in the incidence of the root-knot disease were observed to exist with the highest percent incidence in Raipur and Bemetara (80), followed by Dhamtari (57.14), Rajnandgaon (33.33), while the lowest incidence was observed in district Durg (30) (Figure 1).

The percentage incidence in this investigation was based on the direct examination of root-knots of vegetable crops. A more detailed root-knot nematodes disease survey in five districts of Chhattisgarh central plain region is expected to reveal many more crops to be susceptible.

The populations tentatively identified included *M. incognita*, *M. javanica* and *M. arenaria* (Figures 2 and 3) from the infected roots which occurred both singly or concurrently. *M. incognita* happened to be the most abundant species in the sampled area, single infections of which ranged from 10 to 40% in all surveyed districts. *M. javanica* alone (4.76 to 10%) and *M. incognita* + *M. arenaria* (9.52 to 10%) concurrently were found in Dhamtari and Durg, *M. arenaria* (8.33 to 20%) alone in Dhamtari and Raipur, *M. incognita* + *M. javanica* (40%) in Bemetara, and *M. javanica* + *M. arenaria* (25%) were found in Raipur (Figure 4).

Incidence of root-knot nematode disease (crop wise)

Crop wise variations in the incidences of root-knot nematode infections were observed with an overall incidence of 54.54% (Figure 5). A hundred percent incidence was observed in *Lagenaria siceraria* (Table 1), followed by *Momordica charantia*, *Cucumis sativus* and *Capsicum annum* (67%), *Lycopersicon esculentum* (64%), and *Solanum melongena* (60%), while least incidence was observed in *Musa paradisiaca*, *Daucus*

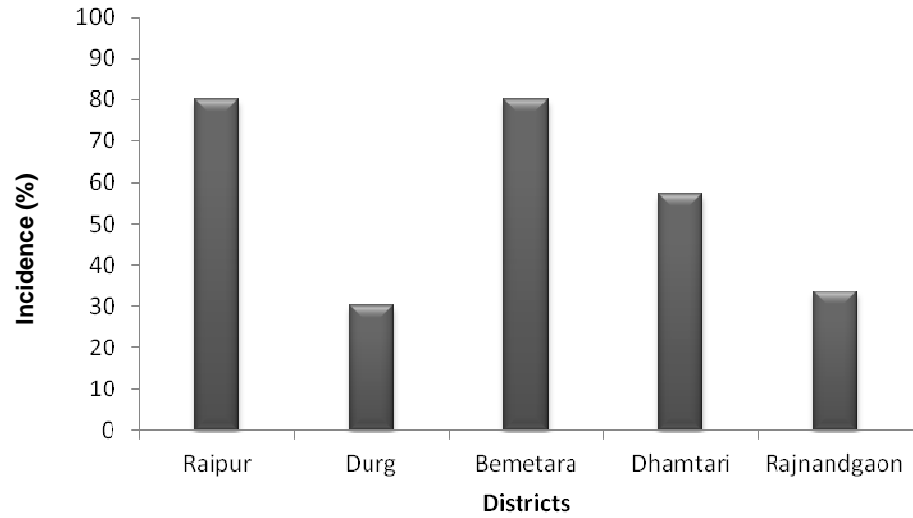


Figure 1. Percent incidence of root-knot nematode infection in some five districts of central plain region of Chhattisgarh, India.

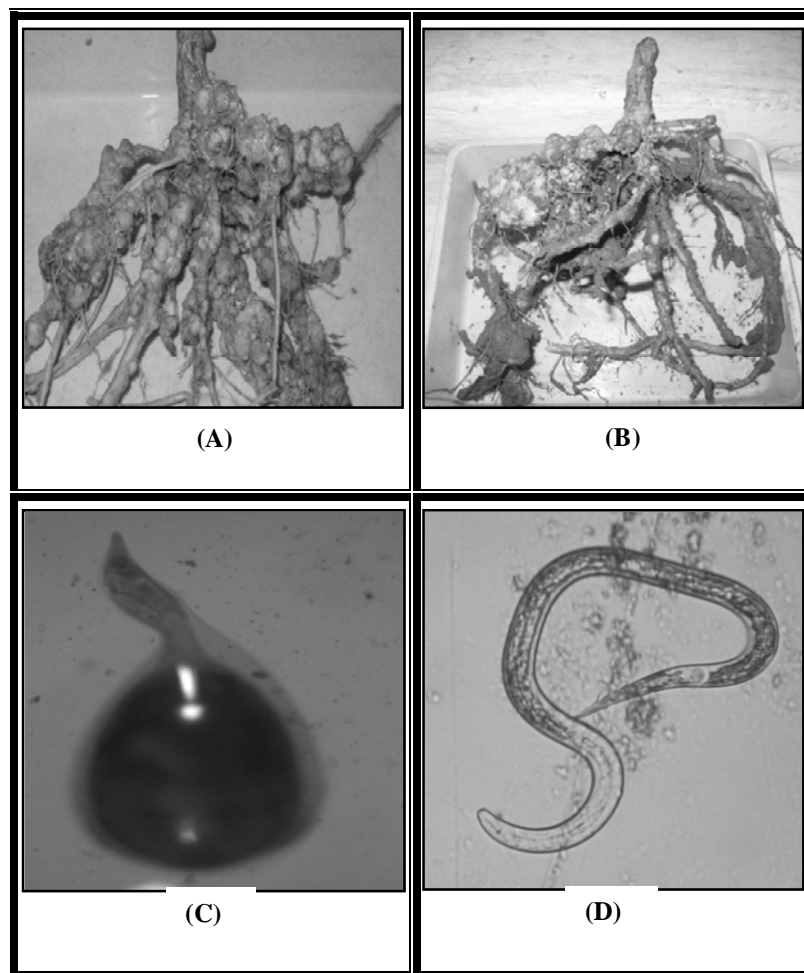


Figure 2. Infected root samples and root-knot nematodes collected from vegetable crop fields; (A) heavily infected bitter melon roots, (B) heavily infected bottle gourd roots, (C) *Meloidogyne* adult female nematode (Magnification; 200X) and (D) *Meloidogyne* 2nd stage juvenile (100X).

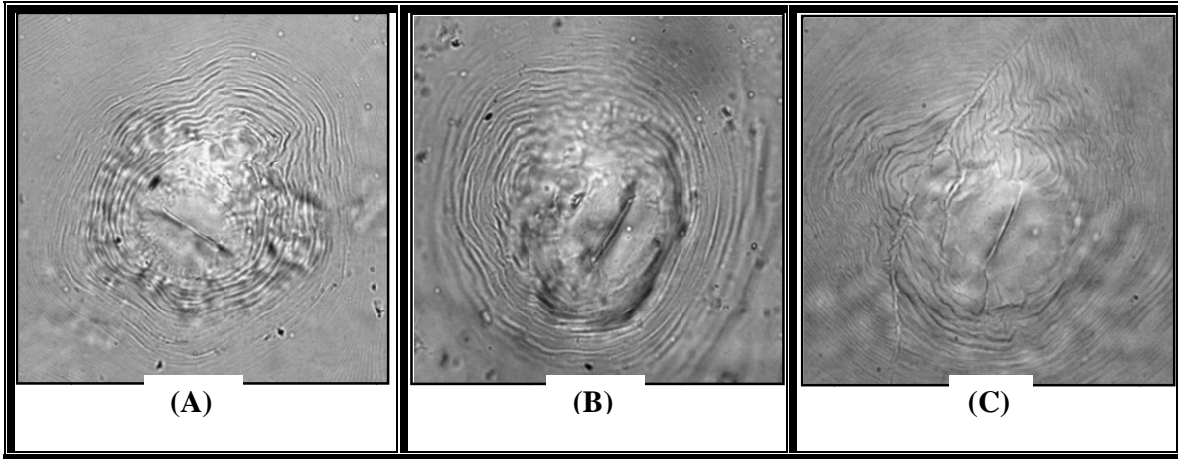


Figure 3. Perineal patterns (400X) of three species of the genus *Meloidogyne* collected from root samples of vegetable crops: (A) *Meloidogyne incognita*, (B) *Meloidogyne javanica* and (C) *Meloidogyne arenaria*.

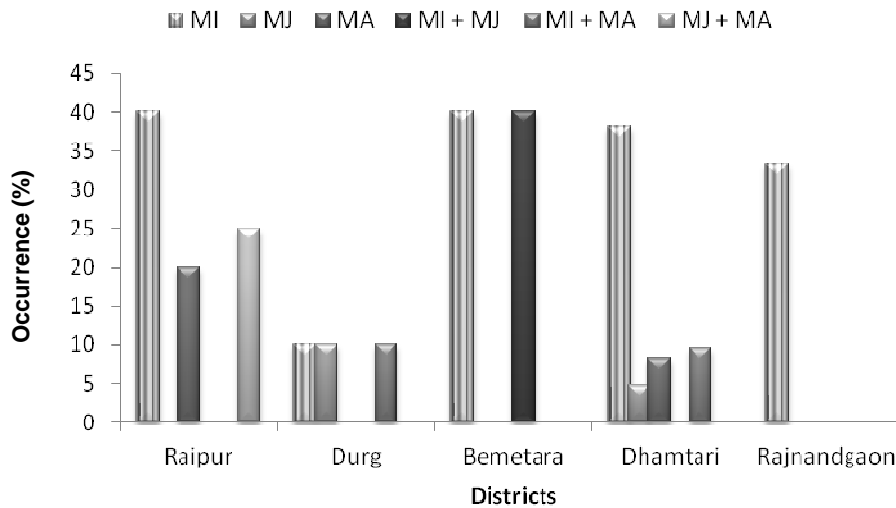


Figure 4. Percent occurrence of *Meloidogyne* species (district wise) in surveyed diseased vegetable crops of central plains region of Chhattisgarh. MI, *Meloidogyne incognita*; MJ, *Meloidogyne javanica*; MA, *Meloidogyne arenaria*.

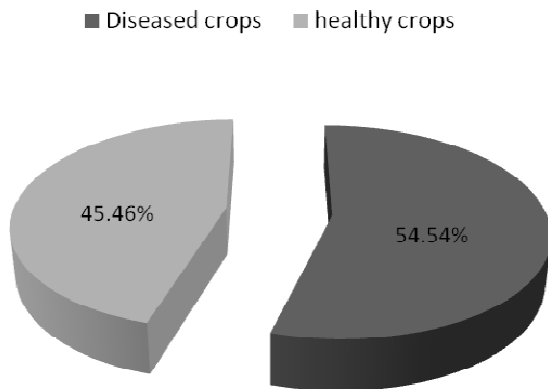


Figure 5. Overall crop wise incidence of root-knot nematode disease in central plains regions of Chhattisgarh.

carota and *Amaranthus tristis* (50%). The other crops such as *Vigna unguiculata*, *Phaseolus vulgaris*, *Glycine max* and *Zinziber officinale* were non-infected (Table 1).

Occurrence and frequency of root-knot nematode species

Occurrence and frequencies of root-knot nematodes (*Meloidogyne* spp.) associated with vegetable crops in the five districts of central plain of Chhattisgarh are presented on Tables 2 and 3. The most frequently occurring root-knot nematode in crop-roots of this area was *M. incognita* (63.33%), followed by *M. arenaria* (20%) and the least frequent was *M. javanica* (16.66%). Table 3 also showed the distribution and overall percent

Table 1. Cropwise percent incidence of root-knot nematode infection in vegetable crops of central plain region of Chhattisgarh (RKN- root-knot nematode, NI- non-infected).

Family	Crop	Common name	RKN incidence (%)
Cucurbitaceae	<i>Lageneria siceraria</i>	Bottle gourd	100
Cucurbitaceae	<i>Momordica charantia</i>	Bitter gourd	67
Cucurbitaceae	<i>Cucumis sativus</i>	Cucumber	67
Solanaceae	<i>Capsicum annuum</i>	Chili	67
Solanaceae	<i>Lycopersicon esculentum</i>	Tomato	64
Solanaceae	<i>Solanum melongena</i>	Brinjal	60
Apiaceae	<i>Daucus carota</i>	Carrot	50
Musaceae	<i>Musa paradisiaca</i>	Banana	50
Amaranthaceae	<i>Amaranthus tristis</i>	Amaranthus	50
Fabaceae	<i>Vigna unguiculata</i>	Cow Pea	NI
Fabaceae	<i>Phaseolus vulgaris</i>	Bean	NI
Fabaceae	<i>Glycine max</i>	Soybean	NI
Zingiberaceae	<i>Zingiber officinale</i>	Ginger	NI

Table 2. Absolute and relative frequency of *Meloidogyne* species associated with vegetable crops of central plain region of Chhattisgarh.

Root-knot nematodes (<i>Meloidogyne</i> spp.)	Absolute frequency	Relative frequency
<i>Meloidogyne incognita</i>	46.34	63.33
<i>Meloidogyne javanica</i>	12.19	16.66
<i>Meloidogyne arenaria</i>	14.63	20
Total	73.17	100

Table 3. Occurrence and distribution of *Meloidogyne* species in roots of vegetable crops belonging to five districts of the central plain region of Chhattisgarh (+ present, - absent, RKN- root-knot nematode).

District	Village	Crop	RKN disease	<i>M. incognita</i>	<i>M. javanica</i>	<i>M. arenaria</i>
1. Raipur	Gatapar	<i>L. esculentum</i>	+	+	-	-
	Mohandi	<i>S. melongena</i>	+	-	-	+
	Kopedih	<i>D. carota</i>	+	+	-	-
		<i>S. melongena</i>	-	-	-	-
		<i>C. annum</i>	+	-	+	+
2. Dhamtari	Khursenga	<i>L. esculentum</i>	+	+	-	-
		<i>M. charantia</i>	-	-	-	-
		<i>C. sativus</i>	-	-	-	-
		<i>P. vulgaris</i>	-	-	-	-
	Birejhar	<i>L. esculentum</i>	+	+	-	-
		<i>S. melongena</i>	+	+	-	+
		<i>S. melongena</i>	+	+	-	-
Mura	Chatoud	<i>C. sativus</i>	+	+	-	-
		<i>M. charantia</i>	+	+	-	-
	<i>L. esculentum</i>	-	-	-	-	
	<i>S. melongena</i>	+	+	-	-	
	<i>A. tristis</i>	+	-	+	-	
Chatoud	<i>P. vulgaris</i>	-	-	-	-	
	<i>L. esculentum</i>	+	+	-	-	

Table 3. Contd.

		<i>C. sativus</i>	+	-	-	+
		<i>S. melongena</i>	-	-	-	-
		<i>S. melongena</i>	+	+	-	-
	Ganeshpur	<i>L. esculentum</i>	-	-	-	-
		<i>C. annum</i>	-	-	-	-
	Kotgaon	<i>S. melongena</i>	+	+	-	+
		<i>P. vulgaris</i>	-	-	-	-
		<i>M. charantia</i>	+	+	-	-
	Kotni	<i>L. siceraria</i>	+	+	-	+
		<i>S. melongena</i>	-	-	-	-
	Kanharpuri	<i>L. esculentum</i>	-	-	-	-
	Patharia	<i>M. paradisiaca</i>	+	-	+	-
	Gomchi	<i>V. unguiculata</i>	-	-	-	-
		<i>Z. officinale</i>	-	-	-	-
		<i>M. paradisiaca</i>	-	-	-	-
	Kumhari	<i>A. tristis</i>	-	-	-	-
		<i>D. carota</i>	-	-	-	-
	Bijanapur	<i>G. max</i>	-	-	-	-
	Dhara	<i>L. esculentum</i>	+	+	-	-
		<i>L. esculentum</i>	-	-	-	-
	Semaria	<i>L. esculentum</i>	+	+	-	-
		<i>L. esculentum</i>	+	+	+	-
	Pendritarai	<i>C. annum</i>	+	+	-	-
	Berla	<i>L. siceraria</i>	+	+	+	-
		<i>S. melongeno</i>	-	-	-	-
Overall percent occurrence			54.54%	43.18%	11.36%	13.63%

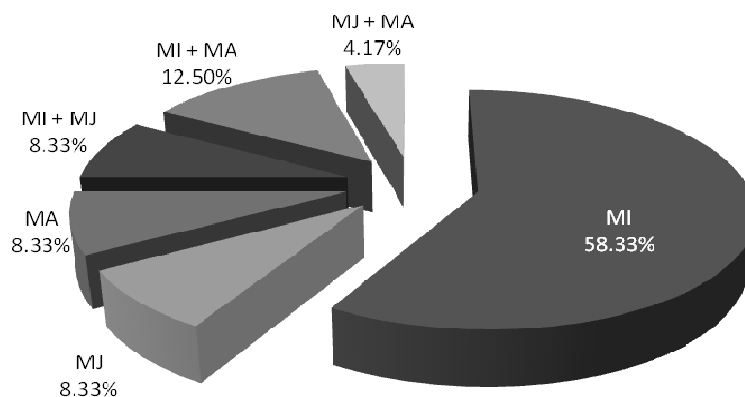


Figure 6. Percent occurrence of *Meloidogyne* species (single and concurrent) in vegetable crops of central plains region of Chhattisgarh. (MI- *Meloidogyne incognita*, MJ- *Meloidogyne javanica*, MA- *Meloidogyne arenaria*).

occurrence of *M. incognita* (43.18%), followed by *M. arenaria* (13.63%) and *M. javanica* (11.36%) in surveyed villages of study areas.

Of all associated *Meloidogyne* species, *M. incognita* constituted 58.33%, *M. javanica* 8.33% and *M. arenaria* 8.33% singly, while, concurrent infections were observed

in some crops, such as; *M. incognita* + *M. javanica* (8.33%), *M. incognita* + *M. arenaria* (12.5%) and *M. javanica* + *M. arenaria* (4.17%) (Figure 6).

Out of 44 samples, 24 samples collected were diseased with the mean nematode population density (NPD) per 200 cc of soil and 10 g of roots was observed

Table 4. Nematode population density per 200 cc soil+10 g roots of diseased vegetable crops belonging to five districts of the central plain region of Chhattisgarh (\pm SE- standard error).

District	Village	Crop	Nematodes/200cc soil and 10 g roots \pm SE
1. Raipur	Gatapar	<i>Lycopersicon esculentum</i>	1439 \pm 64.14
	Mohandi	<i>Solanum melongena</i>	4327 \pm 312.25
	Kopedih	<i>Daucus carota</i>	5715 \pm 541.12
		<i>Capsicum annum</i>	5536 \pm 464.91
2. Dhamtari	Khursenga	<i>Lycopersicon esculentum</i>	1859 \pm 164.20
		<i>Lycopersicon esculentum</i>	1447 \pm 192.42
	Birejhar	<i>Solanum melongena</i>	766 \pm 118.32
		<i>Solanum melongena</i>	2257 \pm 317.59
		<i>Cucumis sativus</i>	1857 \pm 201.21
	Mura	<i>Momordica charantia</i>	870 \pm 102.36
		<i>Solanum melongena</i>	1160 \pm 412.97
	Chatoud	<i>Amaranthus tristis</i>	1446 \pm 124.29
		<i>Lycopersicon esculentum</i>	1758 \pm 86.76
		<i>Cucumis sativus</i>	1669 \pm 97.34
Ganeshpur	<i>Solanum melongena</i>	1462 \pm 264.75	
	Kotgaon	<i>Solanum melongena</i>	5093 \pm 101.53
3. Durg	Kotni	<i>Momordica charantia</i>	9076 \pm 281.38
		<i>Lageneria siceraria</i>	7983 \pm 244.39
	Patharia	<i>Musa paradisiaca</i>	5306 \pm 203.75
4. Rajnandgaon	Dhara	<i>Lycopersicon esculentum</i>	2786 \pm 153.66
5. Bemetara	Semaria	<i>Lycopersicon esculentum</i>	5528 \pm 464.58
		<i>Lycopersicon esculentum</i>	6298 \pm 291.17
	Pendritarai	<i>Capsicum annum</i>	6428 \pm 377.68
	Berla	<i>Lageneria siceraria</i>	6582 \pm 296.78

to vary among the sampling sites (Table 4) ranging from 766 to 9076 which is significantly analyzed (ANOVA $F < 5$ and $P < 0.001$). In *M. charantia* it was highest between 870 and 9076 with average 4973. *L. esculentum* showed 1439 to 6298 NPD with average 3016. NPD of 766 to 5093 with average estimated 2511 was observed in *S. melongena*, 6582 to 7983 with average 7282 in *L. siceraria*, 6428 to 5536 with average 5982 in *C. annum*, 1669 to 1857 with average 1763 in *C. sativus*, 1446 in *Amaranthus*, 5306 in *M. paradisiaca* and 5715 in *D. carota*.

DISCUSSION

The results of the present study show the current status of the incidence and occurrence of root-knot nematodes (*Meloidogyne* spp.) in some districts of central plain regions of Chhattisgarh. During this survey, it was observed that the growths of vegetable plants were highly variable with presence of root galling and arrested root systems. This study provides the quantification of occurrence and density of root-knot nematodes associated with the vegetable crops of this area.

M. incognita, *M. javanica* and *M. arenaria* are a closely

related group causing widespread damage in developing countries (Sasser, 1979). Due to their wide host ranges and concurrent occurrences of virulent races and species, it is difficult to control these pests by management practices like rotation and resistant cultivars (Jepson, 1987; Fargette and Braaksma, 1990; Roberts, 1992). Ehwaeti et al. (1998) reported the multiplication rates root-knot nematode to be rapid on good hosts further increasing the difficulty of preventing crop damage during growing season. Among the *Meloidogyne* spp., *M. incognita* is the most common in vegetable crops worldwide where they parasitize root tissues and induce root galls causing severe damage (Barker and Olthof, 1976; Sasser, 1979; Abawi and Widmer, 2000; Davis et al., 2003; Anwar and Mckenry, 2010; Anwar et al., 2013).

The prevalence of root knot nematode infection in some districts of Chhattisgarh has been earlier reported by Sao et al. 2008, showing high average population density in tomato and bean. However, highest average population has been observed by us in bottle gourd followed by bitter gourd and cucumber. The remarkable occurrence of this nematode in bottle gourd, bitter gourd, cucumber, tomato, brinjal, carrot, amaranthus, chili and banana grown in central region clearly depicts severe damage to these crops by these pests. The reports by

Sahu et al. (2011) on the highest absolute and relative density of *M. incognita* and high prominence value of *M. javanica* among all plant nematodes of Durg district of Chhattisgarh corroborate our present work. Judging the incidence/distribution, mean population and level of damage assessed, the *Meloidogyne* spp. probably appears to be the most important species associated with damage to vegetable production in the state and may be considered to be the most important parasite of the crops under local conditions. In the present study, three species of *Meloidogyne* were recorded including- *M. incognita*, *M. javanica* and *M. arenaria*, all occurring both singly and concurrently in this area. Similar observations were reported by El-Sherbiny (2011) and Ibrahim and Al-yahya (2002) where *M. incognita* and *M. arenaria* showed high percentage of concurrent occurrence. *M. incognita* is recorded as the most frequent and important species of root-knot nematode on locality basis and constitutes a large portion of root-knot population in central plains of Chhattisgarh. *M. arenaria* ranks second in terms of frequency and is relatively less common in the region. Thus, *M. incognita* and *M. arenaria* are also quite frequent and potentially damaging species of the area. Moreover, *M. javanica* is also present in the area with low frequency. *M. incognita* and *M. arenaria* are the common species of this area and therefore need to be controlled efficiently. Severe infection in cucurbits and occurrence of concurrent species in some districts in our data is supported by Kayani et al. (2013) who reported the concurrent occurrence of *Meloidogyne* spp. in Pothowar region of Pakistan and indicated that cucumber was severely infested by root-knot nematodes.

Chhattisgarh is predominantly an agricultural state and central plains are one of its most fertile land areas. The species content of the region may possess an agricultural relationship history. The incidence of *Meloidogyne* spp. on vegetable crops has increased significantly as the acreage allotted to these crops has grown. Our results are in accordance with observations made by Sasser (1989) who conducted a survey of important genera of plant parasitic nematodes including *Meloidogyne* and observed its remarkable representation in most regions of the developed and developing countries all over the world. The findings of this study also clearly demonstrate that *M. incognita* is widely distributed across central plain region of the Chhattisgarh state and involves a wide host range.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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