Fauna of Plant Parasitic Nematodes in the Temperate Region of Japan

1. Surveys in Shizuoka and Kagawa Prefectures

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Abstract

Fauna of harmful nematodes to mainly vegetables and ornamental plants in the temperate region of Japan was investigated compared with that in the subtropics to develop methods of control for the nematodes commonly distributed in both the temperate and subtropical regions. Eight genera of plant parasitic nematodes to crops, including *Aphelenchoides, Criconemella, Helicotylenchus, Meloidogyne, Paratrichodorus, Paratylenchus* and *Rotylenchulus* were detected in vegetable and ornamental plant fields of Shizuoka Prefecture which is located in the temperate region. Of these, *M. hapla* and *M. incognita*, the most harmful nematodes, were detected in rose gardens at a high density. *R. reniformis* and *Pratylenchus* spp. were detected in vegetable and rose fields. *H. dihystera* and *Paratrichodorus porosus* were found infrequently. In Kagawa Prefecture, Shikoku district, 6 genera of nematodes including the same genera or species as those in Shizuoka except for *Tylenchorhynchus* were detected. Among these *M. incognita* was detected mostly in carrot samples at a very high density, causing damage to the crop. *Tylenchorhynchus* spp.and *H. dihystera* were detected on bonsai pine trees, showing yellowish leaves and decayed rootlets. Nematode fauna in both prefectures differed from that on Ishigaki Isl. since the frequency of detection of *Meloidogyne* was higher while that of *Helicotylenchus* and *Tylenchorhynchus* was lower and *Hoplolaimus* and *Paratrophulus* occurring in warm areas were not detected in the former prefectures.

Additional key words: plant parasitic nematodes, Shizuoka Pref., Kagawa Pref., vegetables, flowers, bonsai pine

Introduction

As reported in a previous paper [15], the fauna of nematodes which infest crops in the subtropical zone of Japan (Ishigaki Isl.) including spiral nematodes (*Helicotylenchus* spp.), root-knot nematodes (*Meloidogyne* spp.), reniformis nematode, (*Rotylenchulus reniformis*) and others was investigated. These nematodes which occur widely in the tropical and subtropical regions and are generally considered to belong to the "warm area type", also occur and cause damage to crops in the temperate areas including Shikoku, Kyushu and the southern part of Honshu. Therefore it is important to analyze the nematode species and their geographical distribution to develop methods of control for harmful nematodes to crops not only in the temperate region but also in the subtropics or the tropics. Various kinds of nematodes including new species were recorded and their geographical distribution was analyzed during the implementation of the National Program to Control Soil Nematodes from 1959 until 1964[4]. However, there are few comparative studies on the fauna of nematodes, occurring in the subtropical and temperate zones of Japan. Therefore, the authors carried out a preliminary study on the fauna of plant parasitic nematodes mainly attacking flowers, potted dwarf trees (bonsai) and vegetables in some temperate zones in comparison with that occurring on Ishigaki Isl. in the subtropical zone.

In the present report the results from surveys conducted in some locations of Shizuoka Prefecture in the temperate zone of Honshu and Kagawa Prefecture in the Shikoku district facing the Inland sea (Setonaikai) are described (Fig. 1).

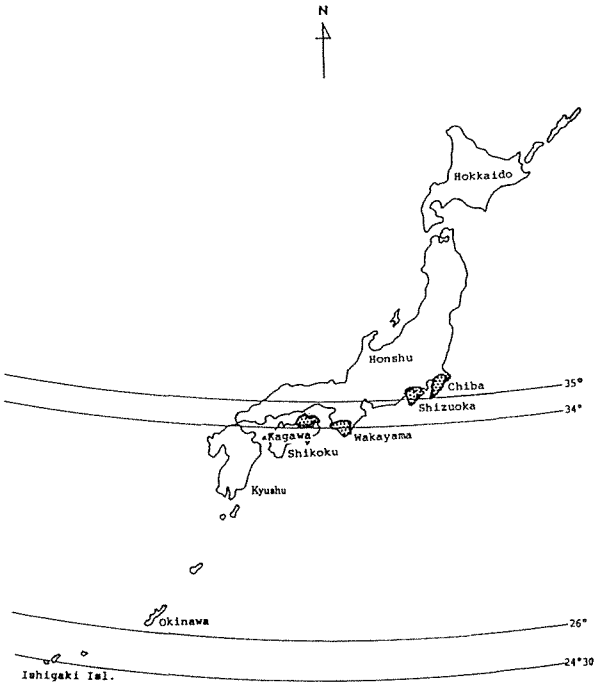

Fig. 1. Location of surveys on nematode fauna in temperate and subtropical zones of Japan.

Materials and methods

Surveys were carried out in fields cultivated with vegetables and ornamental plants in the two prefectures. One soil sample, about 200g, and one rootlet sample, about 5g taken at a depth of 5-20cm were collected, respectively from vegetable fields consisting of volcanic ash in Mishima, and from flower fields in Kannami, Nirayama, Mishima and Shimizu of Shizuoka Prefecture (about 34° 40'N Lat.; mean annual temperature, 16.1° C and mean annual RH, 68%). Similar samples were taken from three potted dwarf pine gardens and five carrot fields around Takamatsu in Kagawa Prefecture (about 34° 20'N Lat.; mean annual temperature, 15.3° C and mean annual RH, 72%).

The nematodes were separated from the soil samples by the Baermann funnel method: an aliquot of 30g of well-mixed soil was placed on a braided dish (9 cm in diameter) covered with a sheet of tissue paper as filter after a glass funnel was filled with water. The sample was allowed to stand for 72 hours at room temperature (20-30℃). The isolated nematodes were killed by heating at 60℃, fixed with TAF solution for five days, mounted in liquid lactophenol and identified under the microscope at the generic level for most of the nematodes, based on their morphological characteristics. The detection rate of some nematodes that were isolated from the same kind

of host plants and identified at the species level, was determined as follows: (number of fields with nematodes/total number of fields examined) x100. *Meloidogyne, Helicotylenchus* and *Rotylenchulus* which were frequently detected in the fields surveyed in Shizuoka and Kagawa as well as Ishigaki Isl. were identified at the species level. *Meloidogyne* spp. were identified based on the morphological observation of the female perineal pattern and other nematodes based on specific morphological characteristics of adult females.

Results

Survey in Shizuoka Prefecture

The results obtained from the survey are presented in Table 1. From each 4 soil samples among all the 10 samples collected from rose gardens under plastic greenhouses in Shizuoka Prefecture, *Meloidogyne hapla* and *M. incognita* were detected. Of these, M. hapla was detected in all 3 rose gardens in Kannami and in 1 garden consisting of volcanic ash soil in Mishima at a fairly or very high density. *M. incognita* was detected in all 2 rose gardens in Shimizu at a high density and in 2 gardens in Nirayama at a low density. *Rotylenchulus reniformis* was detected in a rose garden at a fairly high density and in Japanese radish and spinach fields as well as chrysanthemum and chestnut fields at a low density. *Helicotylenchus dihystera* was detected only in a broccoli field and *Paratrichodorus porosus* in a rose garden. *Paratylenchus* spp. including *P. elachistus* were also detected in a rose garden at a fairly high density though damage by the nematodes was not confirmed. *Pratylenchus* spp., one of the important nematodes harmful to crops, were detected in carrot and spinach fields at a fairly

Table 1. Plant parasitic nematodes detected in vegetable and flower fields in Shizuoka Prefecture.

Location	Crops	*Meloidogyne hapla*	*M.incognita*	*Pratirichodorus porosus*	*Helicotylenchus dihystera*	*Rotylenchulus reniformis*	*Aphelenchoides* spp.	*Criconemella* spp.	*Pratylenchus* spp.	*Paratylenchus* spp.	*Tylenchus* spp.
Mishima	Rose	+++									
	Rose					++			++	++	
	Carrot								++		
	Spinach					+				+	
	Japanese radish					+					
	Chrysanthemum					+			+		
	Japanese radish								+		
	Carrot				+				+		
	Broccoli								+		
	Spring onion						+				
	Cabbage									+	
	Chinese leek							++			+
	Chestnut					+					
Shimizu	Rose		++							++	
	Rose		+++					++		+++	
Kannami	Rose	++		++							
	Rose	+								++	+
	Rose	++								+	
Nirayama	Rose		+						+		+
	Rose		+				++				
	Rose						+++			+	
Detection rate(%)		40/rose	40/rose	10/rose	-	-	-	-	-	-	-

+ : 1-10 nematodes/30g soil, ++ : 11-50 nematodes, +++ : 51 nematodes or more, separated by Baermann funnel method.

high density and on broccoli, Japanese radish and spring onion at a low density. *Aphelenchoides* spp. and *Criconemella* spp. were also detected in rose gardens at a high density but their harmful effect was not confirmed. Although *Tylenchus* spp. were found in some fields, damage to crops was not confirmed.

Survey in Kagawa Prefecture

The results obtained are shown in Table 2. In 4 fields among 5 carrot fields, *Meloidogyne incognita* was observed at a high density, with a detection rate of 80%. Serious damage to carrot by this nematode was actually observed especially in Hayashida and Takaya where *M. incognita* occurred at a very high density. *Helicotylenchus dihystera, Criconemella* spp. and *Tylenchorhynchus* sp. with a round broad tail were detected in one of 3 gardens of bonsai pines surveyed, at a high density, respectively. *Rotylenchulus reniformis* was detected only in one carrot field, and *Pratylenchus* spp. on one bonsai pine at a low density.

Discussion

Kobayashi(1992) reviewed the major nematodes harmful to crops in the Tokai district, in the temperate zone of Japan, including Shizuoka Prefecture[6]. In Shizuoka Prefecture vegetable damage by *Meloidogyne incognita* and *M. hapla*[1], as well as *Pratylenchus fallax* and *P. penetrans*[8] and strawberry damage by *Aphelenchoides besseyi*[5], A. *fragariae*[16] and *Nothotylenchus acris*[12], paddy rice damage by *A. besseyi*[2,7] and damage of chrysanthemum by *A. ritzemabosi*[9,10], *P. penetrans* and *P. fallax*[9], etc. have been mainly reported. Fauna of main pest nematodes in Shizuoka is probably characterized by *Meloidogyne incognita* which occurs commonly and attacks various kinds of crops, *Pratylenchus* spp. which are harmful to chrysanthemum and vegetables, as well as *Aphelenchoides* spp. which parasitize leaves and stems of rice, ornamental plants and strawberry. Such large or inactive nematodes as *Xiphinema* spp. or ring nematodes including *Criconemella* spp., *Ogma* spp. etc., could not be separated from soil by using only the Baermann method. Comparison of nematode detection px ate is not significant at the genus level or in the case of nematodes collected from different kinds of host plants. Therefore, the detection rate was determined in only *Meloidogyne hapla* and *M. incognita* parasitizing rose. Although this survey covered a limited area, *M. incognita, M. hapla* and *Pratylenchus* spp. were considered to be important pest nematodes also for rose cultivated in greenhouse. *Rotylenchulus reniformis* may be harmful to vegetables in this region. The collection of samples in a limited area and/or not

Table 2. Plant parasitic nematodes detected in potted dwarf pine gardens and carrot fields in Kagawa Prefecture.

Location	Crops	*Meloidogyne incognita*	*Helicotylenchus dihystera*	*Rotylenchulus reniformis*	*Criconemella* spp.	*Pratylenchus* spp.	*Tylenchorhynchus* sp.
Takamatsu	Pine						++
	Pine				++		
	Pine		+++			+	
Hayashida	Carrot	+++					
Ejiri	Carrot	++		+			
Saijo	Carrot				+		
Kamiya	Carrot	++					
Takaya	Carrot	+++					
Detection rate(%)		80/carrot	30/pine	20/carrot	-	-	-

+ : 1-10 nematodes/30g soil, ++ : 11-50 nematodes, +++ : 51 nematodes or more, separated by Baermann funnel method.

during the cropping season may account for the fact that *Meloidogyne incognita*, the most common pest nematode, was not detected in any vegetable fields. In Kagawa Prefecture it was reported that *M. incognita* was harmful to carrot. The bonsai pine trees showed yellowish changes on leaves and growth inhibition of rootlets, suggesting that such nematodes as *Criconemella* spp., *H. dihystera*, and *Tylenchorhynchus* sp. which were collected from soil samples from bonsai pines at a high density were responsible for these symptoms. Of these, though *Tylenchorhynchus* sp. with a broad, round tail which was collected from the pines has not been identified yet, it is probably a very rare nematode in Japan.

From bonsai pines in Kagawa for exportation, 6 genera of nematodes including *Criconemella, Helicotylenchus, Meloidogyne, Tylenchorhynchus*, etc. were already reported by the Plant Protection officials[3].

Watanabe and Toida(1983) reported the presence of plant parasitic nematodes such as *Paratylenchus elachistus, Gracilacus yokooi, Helicotylenchus erythrinae , Xiphinema bakeri, X. insigne, Tylenchorhynchus* sp. and others in mulberry fields in Kagawa Prefecture[14], which indicates that the nematode fauna in vegetables and bonsai pine is different from that in mulberry fields. According to Matsuzaki[11], *Meloidogyne incognita* occurred widely in upland fields and well-drained paddy fields once used for rice cultivation throughout the Shikoku district and was harmful to crops including cucumber, eggplant, tomato, watermelon, etc. He also reported that serious damage of sweet potato, Japanese radish, carrot by this nematode was commonly observed in the fields with sandy soil of Kagawa Prefecture. Such damage, mainly attributable to *M. incognita*, has become a serious problem, especially in recent years, due to the increase in the cultivation of upland crops and the decrease in the area of paddy fields. As a result, the incidence of damage caused by *Meloidogyne* spp. has increased.

In reference to the nematode fauna occurring on Ishigaki Island in the subtropical zone of Japan which was described previously[15], *Helicotylenchus* spp. detected in most of the upland fields surveyed on Ishigaki was observed only in one soil sample in Shizuoka and Kagawa, respectively. *Rotylenchulus reniformis* and *Tylenchorhynchus* spp. which were detected in a fairly high frequency on Ishigaki Isl. was not observed in Shizuoka and was detected only on one bonsai pine in Kagawa. *Meloidogyne arenaria*, and *M. javanica* as well as *M. incognita* were detected on Ishigaki Isl. while *M. hapla* which was detected in Shizuoka was not found on the island. Such nematodes as *Hoplolaimus* sp. and *Paratrophulus* sp. which occur in warm areas including Ishigaki (Table 3)[13,15] were not observed in this survey. The nematode fauna in Ishigaki Isl. which includes the above nematodes is different from the fauna in Shizuoka and Kagawa although the difference in the *Meloidogyne* spp. between both areas was not appreciable.

Further surveys should be conducted in a larger number of sampling sites to determine the species and geographical distribution of harmful nematodes to crops.

Acknowledgment

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Table 3. Plant parasitic nematodes detected on Ishigaki island and their detection rate.

Crops	Location	*Meloidogyne* Mi Mj Ma ?	*Pratylenchus*	*Tylenchorhynchus Paratrophulus*	*Hoplolaimus*	*Helicotylenchus*	*Rotylenchulus*	*Paratylenchus*	*Criconemella*
Sweet potato	Maisatokawarabaru					+	+		
Sweet potato	Tonoshiro					+	+		
Sweet potato	Nakura					+	+		
Sweet potato	Maisato-ohkawa						+		
Sweet potato	Yonehara	+				+	+		
Sweet potato	Omoto			+	+	+			
Taro	Hirakubosaki					+			
Carrot	Maisato-ohkawa					+			
Ginger	Yoshiharanakabushi					+			
Ginger	Kapira			+		+		+	
Pumpkin	Maisat-ohkawa						+		
Pumpkin	Omoto		+	+		+	+		
Watermelon	Omoto					+	+		
Pineapple	Maisatokawarabaru					+			
Pineapple	Nakura					+	+		+
Pineapple	Bannatake					+	+		
Banana	Yoshiharanakabushi	++++				+	+	+	+
Banana	Kapira					+	+		
Banana	Shiraho					+			+
Loquat	Yoshiharanakabushi					+			
Mango	Bannatake			+		+			+
Shiikuwasha	Yoshiharanakabushi				+		+		
Guava	Maisatokawarabaru		+			+			+
Solomon Islands ivy arum	Yoshiharanakabushi					+		+	+
Flaming vriesia	Omoto		+			+	+		+
Mulberry	MaisatoKawarabaru		+	+	+	+		+	+
Muberry	Bannatake			+		+			+
Sugarcane	MaisatoKawarabaru		+			+			+
Sugarcane	Yoshiharanakabushi	++				+			+
Sugarcane	Kapira			+		+			+
Sugarcane	Omoto			+	+	+			
Sugarcane	Shiraho		+			+		+	+
Tobacco	Hirai		+	+		+	+		+
Rhodesgrass	Kahira		+			+			
Detection rate(%)		21.0	23.5	26.5	11.8	91.2	44.1	14.7	41.2

Mi:*Meloidogyne incognita*, Mj: *M. javanica*, Ma: *M. arenaria*, ? : unknown
(by Yamamoto & Minagawa,1994)

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本邦温暖地の畑地における植物寄生線虫相

1．静岡および香川両県における調査

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摘　要

熱帯あるいは亜熱帯における作物加害線虫の中には本邦温暖地のそれと共通する種類が少なくない。そこで、これら有害線虫の防除法を確立するための基礎資料を得る目的で、本邦温暖地の畑地における植物寄生線虫相の調査を行った。先ず静岡および香川両県の主として野菜と花きの圃場において線虫相を調べた。静岡県からはネコブセンチュウ（*Meloidogyne* spp.）ネグサレセンチュウ，ニセフクロセンチュウ（*Rotylenchulus reniformis*）など主要有害線虫に加えてナミラセンセンチュウ（*Helicotylenchus dihystera*），ナガイモユミハリセンチュウ（*Paratrichodorus porosus*），ハセンチュウ（*Aphelenchoides* spp.），ピンセンチュウ（*Paratylenchus* spp.）などが検出された。特に函南，韮山，清水などのビニールハウス栽培のバラから多数のキタネコブセンチュウ（*M. hapla*）とサツマイモネコブセンチュウ（*M. incognita*）が検出されたことと，ニセフクロセンチュウおよびネグサレセンチュウが各種の野菜圃場から検出されたのが目立った。

香川県からはサツマイモネコブセンチュウ，ラセンセンチュウ，ニセフクロセンチュウなど静岡と同様の有害線虫が見いだされたほか，生育不良の盆栽マツからイシュクセンチュウ（*Tylenchorhynchus* spp.）が検出された。特に林田，江尻，神谷，高屋などの地域で調査したニンジン圃場のほとんどから多数のサツマイモネコブセンチュウが検出され，ニンジンに被害が認められた。

この両県のそれぞれ一部地域から検出された線虫の種類は石垣島のそれらと比べ，ネコブセンチュウの検出頻度が高く，しかもキタネコブセンチュウが見られたこと，イシュクセンチュウ（*Tylenchorhynchus* spp.）とラセンセンチュウの検出率が低いこと，さらに暖地型線虫とされるヤリセンチュウ（*Hoplolaimus* spp.），リュウキュウイシュクセンチュウ（*Paratrophulus* sp.）などが検出されなかったなどの点で異なる。なお，この調査では線虫の分離をベルマンロート法のみで行ったことと，調査標本数が少なかったために有害線虫のうち，特にオオガタハリセンチュウ，ワセンチュウなど活動性の鈍い線虫を検出することができなかったので，今後は遠心浮遊法，ふるい分け法などの分離法もとり入れ，より多くの土壌標本から線虫を分離し，さらに厳密な線虫相の調査を行うことが必要である。

キーワード：植物寄生線虫，千葉県，温暖地，花き，野菜