MARDI Res. Bull. (1987) 15(1), (37–44)

POPULATION DEVELOPMENT OF ROOT-KNOT NEMATODES IN TOBACCO FIELDS IN KELANTAN DURING TWO CONSECUTIVE YEARS

P.M. YUEN* and A.S. ENON**

Keywords: Meloidogyne sp., Population development, Weeds.

RINGKASAN

Satu kajian selama dua tahun telah dijalankan di sembilan buah ladang tembakau di Bachok dan Pasir Puteh, Kelantan. Dua spesies nematod puru akar, *Meloidogyne incognita* dan *M. javanica,* didapati menyerang pokok tembakau varieti TAPM 36. Serangan pada pokok tembakau boleh bermula dalam batas semaian, kerek atau di ladang. Populasi larva nematod ini mencapai kemuncak pada bulan kedua atau ketiga selepas peringkat mengubah. Semasa ladang dibiarkan kosong iaitu selepas penanaman tembakau larva nematod puru akar didapati menyerang rumpai dan sebanyak 23 spesies rumpai telah menjadi perumah gantian. Rumpai yang boleh hidup dalam air bertakung membolehkan nematod hidup pada musim banjir.

INTRODUCTION

Root-knot nematode (*Meloidogyne* spp.) is a common pest of tobacco and is found in many places in Peninsular Malaysia where the crop is grown (ABDUL KARIM, 1982). Tobacco is grown in the states of Kelantan, Terengganu, Pahang, Johore, Kedah, Perlis, Negeri Sembilan and Malacca by some 50 000 families (ANON., 1984). However, no local data are available on the monetary value of crop loss caused by nematodes on tobacco. Reports from the Agricultural Extension Service of North Carolina state that nematode problems in 1983 caused 15% of all disease losses in flue-cured tobacco, estimated at US $8.5 million (POWELL, 1984). Also, no study has yet been done locally to trace the origin of the main sources of infection by *Meloidogyne* larvae and the fate of the nematode population during the tobacco off-season. Such knowledge is fundamental in helping to formulate control measures to be taken at the various stages of infestation of the tobacco crop. This study was carried out to elucidate the problem.

MATERIALS AND METHODS

Nine farms were randomly selected at Bachok and Pasir Puteh, the two major tobacco-growing districts in Kelantan. The sites selected were at Bachok – Pengkalan Kassim, Pauh Sembilan, Badak, Wakaf Zain and Kg. Telok; Pasir Puteh – Batu Pa'ka, Batu Sebutir (Padang Pak Amat), Chengal Pulas and Kg. Kelubi. At Bachok, the study began in December 1983 and ended in October 1985 while that at Pasir Puteh started in April 1984 and ended in October 1985. Sampling was conducted monthly, using a tube auger of 2.3 cm diameter and 30 cm length. For each farm surveyed, soil samples were collected at three stages of the crop, *viz.*, the sowing bed, polybag (kerek) and the field. In the sowing bed, soil cores were taken at random across the bed to make a two-litre composite soil sample. Sampling was done just after the bed was prepared, before sowing of seeds. In the polybag stage, samples of soil were taken from the polybags before transplanting of the seedlings. Twenty polybags were picked at random and the entire contents of each bag were collected. The soil was then thoroughly mixed and a two-litre composite sample taken.

The farms surveyed averaged 30 m x 30 m in area. On each farm, a systematic sampling method was employed. A two-litre composite sample was taken from each of five areas (6 m x 6 m each); four at each

*Central Research Laboratories Division, MARDI, Serdang, Selangor, Malaysia.
**Tobacco Division, MARDI, Telong, Kelantan, Malaysia.

corner of the field, and one in the centre. During the tobacco season, soil cores were taken 6–20 cm from the base of the plant at the edge of the root system, the distance increased with size of the plant. In the off-season, samples were taken from the same area where the tobacco had grown.

The soil samples were taken back to the laboratory and processed to extract the nematodes. From each sample, a 200-millilitre subsample was processed by the extraction method modified after WHITEHEAD and HEMMING (1965) and the resultant suspension was passed through a nest of four 45-micron sieves. Bioassays for root-knot larvae were made from every soil sample by planting tomato seedlings (MT 11 variety) in each of three 200-millilitre plastic cups filled with soil from the relevant sample. The gall index of the tomato root system was determined 35 days after planting, using the rating chart of BRIDGE and PAGE (1980). This chart scored root systems from a scale of 0 (no infection) to a maximum of 10 (most heavily galled). Adult *Meloidogyne* females in the roots were stained in lactophenol blue or acid fuchsin and perineal patterns dissected for species identification (SOUTHEY, 1970).

During the survey, the weed species growing in the sampled areas were identified and their roots examined for root-knot infection. Weeds which bore galls containing mature *Meloidogyne* females with eggs were regarded as hosts. A similar method was used by researchers in India to identify weed hosts of *M. incognita* (SUNDARARAJU, SOSAMMA and KOSHY, 1985) and *M. javanica* (MANGAT, GUPTA and BHATTI, 1985).

RESULTS AND DISCUSSION

During the two-year study, root-knot nematodes were found at eight of the nine sites visited, the exception being Kg. Kelubi where no *Meloidogyne* sp. was recorded throughout the survey *(Table 1)*. Based on the perineal patterns of the adult females, *Meloidogyne incognita* was identified at eight sites and in five of these, there was mixed infection with *M. javanica*. At Pengkalan Kassim, Kg. Telok and Chengal Pulas, only *M. incognita* was identified during the two-year study. At Batu Pa'ka, only *M. javanica* was detected during the first year of the survey but *M. incognita* was found as well on the second tobacco crop. Throughout the study, the tobacco variety grown by the farmers was TAPM 36.

Table 1. *Meloidogyne* spp. observed at survey sites in Bachok and Pasir Puteh, Kelantan

Site	*M. incognita*	*M. javanica*
Bachok		
Pengkalan Kassim	+	
Pauh Sembilan	+	+
Badak	+	+
Wakaf Zain	+	+
Kg. Telok	+	
Pasir Puteh		
Batu Pa'ka	+	+
Batu Sebutir	+	+
Chengal Pulas	+	
Kg. Kelubi		

The monthly larva counts and bioassay scores in Bachok and Pasir Puteh are shown in *Tables 2* and *3* respectively. At the start of the survey, sampling of the sowing beds showed that root-knot larvae were present in five of the nine farms. The sowing beds at Pengkalan Kassim, Pauh Sembilan, Badak, Batu Sebutir and Chengal Pulas showed the presence of *Meloidogyne* larvae in direct counts and/or bioassay scores. This shows that the soil used in the sowing bed is one of the sources of nematode infection of the tobacco crop. This comes about because such soil is usually taken from fallow land (where *Meloidogyne* sp. can thrive on weeds) or from places where a nematode-infected crop has been grown before, *e.g.*, brinjal, watermelon, sweet potato or okra. In either case, the inadvertent use of this soil by farmers presents the phytoparasites with a fresh and susceptible host.

About a month later, the seedlings were transplanted from the beds to poly-bags. The soil in the polybags was sampled

Table 2. Soil population of *Meloidogyne* spp. larvae over two consecutive tobacco crops at 5 sites in Bachok, Kelantan

Sampling		Mean larva no. per 200 ml soil (Mean bioassay score in parenthesis)				
		Pengkalan Kassim	Pauh Sembilan	Badak	Wakaf Zain	Kg. Telok
Tobacco season	(1983/84)	Tobacco	Tobacco	Tobacco	Tobacco	Tobacco
Sowing bed	Dec. 83	16 (4)	0 (0.3)	16 (3)	0 (0)	0 (0)
Polybag	Jan. 84	17 (0.7)	0 (0.3)	0 (0.3)	0 (0)	0 (0)
F1 (pre-plant)	Jan.	3 (0.1)	3 (0)	0 (0)	0 (0)	20 (0)
F2	Feb.	3 (0)	0 (0)	3 (0)	0 (0)	7 (0)
F3	Mar.	0 (0.1)	187 (0.8)	787 (2.7)	13 (0)	33 (0.4)
F4	Apr.	73 (0.5)	220 (0.9)	240 (1.7)	7 (0.1)	29 (0.2)
Off-season		Sweet potato	Fallow	Fallow	Pumpkin	Fallow
OS1	May	13 (0)	13 (0)	73 (0.5)	0 (0)	33 (0.2)
OS2	Jun.	6 (0)	13 (0.1)	33 (0.3)	0 (0)	20 (0.1)
OS3	Jul.	0 (0)	33 (0.3)	27 (0.3)	13 (0.1)	0 (0)
OS4	Aug.	0 (0)	0 (0)	126 (2.3)	0 (0)	80 (1.2)
OS5	Sept.	13 (0.8)	46 (1.9)	67 (2.9)	0 (0)	26 (1.0)
OS6	Oct.	127 (1.4)	93 (2.4)	60 (2.2)	0 (0)	17 (0.1)
OS7	Nov.	267 (3.1)	80 (4.6)	187 (1.3)	0 (0)*	0 (0)*
OS8	Dec.	0 (1.3)*	0 (0.1)*	0 (0.4)*	0 (0)*	0 (0)*
Tobacco season	(1984/85)	Tobacco	Tobacco	Tobacco	Tobacco	Tobacco
Sowing bed	Dec. 84	0 (1.3)	33 (2.4)	0 (1.3)	0 (0.3)	0 (1)
Polybag	Jan. 85	0 (2.7)	0 (0.7)	0 (0.7)	0 (0)	133 (0)
F1 (pre-plant)	Jan.	7 (0.6)*	0 (0)*	7 (0.1)*	0 (0)*	100 (0)
F2	Feb.	0 (0)	40 (1.8)	0 (0.1)	0 (0)	27 (0)
No sampling	Mar.	*	*	*	*	*
F3	Apr.	0 (0)	0 (0)	0 (0)	0 (0)	7 (0.2)
Tobacco replant		Fallow	Tobacco	Fallow	Tobacco	Tobacco
Sowing bed	Apr.	–	0 (0)	–	0 (0.7)	0 (2.3)
Polybag	May	–	0 (0)	–	0 (0)	67 (3)
F1	May	20 (0)	47 (0)	20 (0.3)	0 (0)	0 (0)
F2	Jun.	47 (0.1)	20 (0.3)	113 (1.1)	0 (0)	0 (0)
F3	Jul.	40 (0.8)	73 (0.3)	520 (2.5)	0 (0)	33 (0.7)
F4	Aug.	40 (0.5)	67 (0.4)	187 (2.9)	27 (0)	33 (0.7)
Off-season		Fallow	Fallow	Fallow	Fallow	Fallow
OS1	Sept.	7 (0.2)	7 (0.1)*	100 (2.4)	0 (0)*	7 (0)
OS2	Oct.	0 (0)	*	0 (0)	13 (0)	20 (0)

* = Field flooded
F1–F4 = Field sampling during the tobacco crop
OS1–OS8 = Field sampling during the off-season

and again, *Meloidogyne* larvae were detected in five nurseries, the samples giving positive results in soil counts and/or bioassays. These farms were at Pengkalan Kassim, Pauh Sembilan, Badak, Batu Pa'ka and Batu Sebutir. Thus, the polybag stage is the second phase when tobacco seedlings are at risk to infection.

The third soil sampling was made after the fields had been rotovated and ridged, ready for transplanting of the tobacco seedlings. This preplant count revealed the presence of root-knot larvae in four of the nine fields. Most of the fields had populations of less than 50 larvae/200 ml soil with the exception of Batu Pa'ka which had 100 larvae/200 ml soil. This is the third phase of the crop in which tobacco plants are exposed to infection by *Meloidogyne* species.

Soil sampling was continued monthly throughout the growth of the tobacco crop at all the nine farms. Generally, it was

Table 3. Soil population of *Meloidogyne* spp. larvae over two consecutive tobacco crops at 4 sites in Pasir Puteh, Kelantan

Sampling		Mean larva no. per 200 ml soil (Mean bioassay score in parenthesis)			
		Batu Pa'ka	Batu Sebutir	Chengal Pulas	Kg. Kelubi
Tobacco season	(1984/1985)	Tobacco	Tobacco	Tobacco	Tobacco
Sowing bed	Apr. 84	0 (0)	16 (0.3)	33 (0)	0 (0)
Polybag	May	100 (0)	33 (0.3)	0 (0)	0 (0)
F1 (pre-plant)	Jun.	100 (0.5)	0 (0)	0 (0)	0 (0)
F2	Jul.	7 (0)	40 (0.2)	47 (0)	0 (0)
F3	Aug.	13 (0.2)	20 (0.4)	7 (0.2)	0 (0)
F4	Sept.	27 (0.2)	100 (1.3)	147 (0.8)	0 (0)
Off-season		Paddy	Fallow	Paddy	Paddy
OS1	Oct.	60 (0.2)	0 (0)	93 (0.8)	0 (0)
OS2	Nov.	0 (0)*	0 (0)*	0 (0)*	0 (0)*
No sampling	Dec.	*	*	*	*
OS3	Jan. 85	0 (0)*	53 (2.7)	146 (1.5)*	0 (0)*
OS4	Feb.	120 (1.6)	20 (2.3)	0 (0)	0 (0)*
Tobacco season	(1985)	Tobacco	Tobacco	Tobacco	Fallow
Sowing bed	Mar.	0 (0)	0 (0)	33 (0)	–
Polybag	Apr.	433(–)	0 (0.7)	33 (0)	–
F1 (pre-plant)	Apr.	7 (0)	13 (0.4)	0 (0)	0 (0)
F2	May	47 (1.7)	20 (0)	0 (0)	0 (0)
F3	Jun.	0 (0)	47 (0)	0 (0)	0 (0)
F4	Jul.	1 173 (1.4)	40 (0.1)	13 (0)	0 (0)
Off-season		Fallow	Fallow	Fallow	Fallow
OS1	Aug.	7 (0.4)	87 (2.5)	60 (0.9)	0 (0)
OS2	Sept.	13 (0.1)	7 (0.1)	7 (0.1)	0 (0)
OS3	Oct.	0 (0)	7 (0)	7 (0)	0 (0)*

* = Field flooded
F1 – F4 = Field sampling during the tobacco crop
OS1 – OS4 = Field sampling during the off-season

observed that the nematode larval count peaked at either the second or third month after transplanting *(Tables 2* and *3)*. This pattern of root-knot population build-up is commonly observed in annual crops where maximum levels are attained at midseason or near harvest (BARKER, 1985). After the final reaping, the tobacco stalks were uprooted and removed. Some of the fields were then left fallow while others were planted with other crops. Paddy *(Oryza sativa)* was grown in Pasir Puteh district while sweet potato *(Ipomoea batatas)* and pumpkin *(Cucurbita pepo)* were planted at Bachok. At Bachok, the sweet potato grown at Pengkalan Kassim was infected by root-knot larvae from the previous tobacco crop, resulting in an infection which peaked six months later *(Table 2)*. At Wakaf Zain, *Meloidogyne* larvae were detected on the pumpkin crop in the third month after planting. The crop was not well maintained and was subsequently abandoned by the farmer. The pumpkin plants were soon smothered by weeds and were also affected by an unidentified disease which eventually killed off the majority of the plants. Subsequently, no root-knot larvae were detected in the plot up to the end of the year. No *Meloidogyne* larvae were present in soil counts and bioassays. Weeds which were alternate hosts were present but were found to be non-infected.

In the three fields that were left fallow (Pauh Sembilan, Badak and Kg. Telok), the nematode population did not die after removal of the tobacco crop. Examination of the weeds growing in the fields showed the presence of galls, adult females and eggs in some of the weed roots.

Table 4 presents a list of the common weeds found at the observation sites. A total of 38 weed species belonging to 17 families were identified. Of these, 23 species or 60.5% were observed to be hosts of *Meloidogyne* species. These host weeds were from the majority of families listed except for the Commelinaceae and Verbenaceae. The same species of weeds was not found at every site. Some weed species were found in most fields while others occurred in one locality only. The presence of weeds which served as alternate hosts, enabled nematodes to survive the fallow period. Judging from gall size and number, the various weed species may vary in their susceptibility to the nematodes. Weeds such as *Leucas zeylanica, Portulaca oleraceae* and *Vernonia cinerea* produced large coalescent galls bearing numerous egg masses while *Cleome burmanni* and *Physalis minima* were regarded as poor hosts since galls were few and seldom observed. Slender weeds such as *Hedyotis corymbosa* with fine roots produced galls which were barely visible to the naked eye.

The presence of a weed which is known to be a host of *Meloidogyne* sp., does not necessarily mean that the nematode must be present as well. For example, no root-knot infection was recorded at Kg. Kelubi even though six host weed species were present. These particular weeds had previously been identified as hosts in other farms surveyed which had *Meloidogyne* infection.

More weeds which were *Meloidogyne* hosts, were recorded in Bachok district (21 species) than in Pasir Puteh (16 species) *(Table 4)*. This accounted for the generally higher larval population in the farms at Bachok during the tobacco off-season when compared with Pasir Puteh. The fewer host weeds, coupled with the planting of paddy in Pasir Puteh, resulted in a lower larval population (cf. *Tables 2* and *3*). Nevertheless, the nematodes in the fields that were under paddy cultivation did not die off completely in the flooded plots. Root-knot larvae were seen in soil extracts and confirmed by bioassays of the same soil samples. The nematodes managed to survive on weeds which were tolerant to waterlogging, such as *Ludwigia hyssopifolia, Cyperus compressus, C. iria* and *C. zollingeri.* As an example, the presence of similar weeds in Chengal Pulas enabled the nematode population to attain 146 larvae/200ml soil when the plot was under paddy *(Table 3)*. No root-knot infection was observed on paddy roots. Thus, although flooding is a method for nematode control, the presence of such host weeds can partly negate the effect. Such weeds enable a residual population to survive during the annual floods in December when most tobacco fields in Kelantan are flooded. This survival is evidenced by the existence of larvae in the soil after the flood water has receded, before planting of the next crop.

The presence of the same species of weeds which are alternate hosts to root-knot nematodes, has been recorded in other countries as well. For example, Portulaca oleraceae, Eclipta alba and *Echinochloa colonum* are identified as hosts of *M. incognita* in the Philippines by VALDEZ (1968), while *Ageratum conyzoides* and *Mimosa pudica* are listed as hosts of *Meloidogyne* sp. in Hawaii (RAABE, 1963). In Malaysia, with further surveys of tobacco farms, more weed species will undoubtedly be found to be hosts of the polyphagous *Meloidogyne* species.

The results of the nematode survey in 1985 showed a similar pattern as that of the previous year's tobacco crop, namely that larvae can infect the crop at any or all crop stages (sowing bed, polybags or field). Sometimes larvae were absent in soil counts but were found to exist in bioassays *(Tables 2* and *3)*. However, in March 1985, many of the tobacco plantings in Bachok were destroyed by non-seasonal floods, including those in the observation sites. Following this calamity, another tobacco crop was sown but farmers at Pengkalan Kassim and Badak decided not to replant *(Table 2)*. Subse-

Table 4. Weeds observed at survey sites in Bachok and Pasir Puteh, Kelantan

Family	Botanical name	Bachok					Pasir Puteh			
		Peng. Kassim	Pauh Sembilan	Badak	Wakaf Zain	Kg. Telok	Batu Pa'ka	Batu Sebutir	Chengal Pulas	Kg. Kelubi
Capparidaceae	*Cleome burmanni**				+	+	+		+	
	*C. rutidosperma**		+	+	+	(+)	+	+	+	
Commelinaceae	*Aneilema nudiflorum*	+		+		+	+	+		
	Commelina nudiflora		+		+	+	+			
Compositae	*Ageratum conyzoides**	+	+	+		+			+	
	*Eclipta alba**	+	+			+			+	+
	Spilanthes acmella								+	
	*Vernonia cinerea**								+	
Cyperaceae	*Bulbostylis barbata*	+		+	+			+		
	*Cyperus compressus**			+		+		+		
	*C. iria**					+	+		+	
	C. rotundus									+
	*C. zollingeri**				+					
	*Fimbristylis globulosa**					+				+
Euphorbiaceae	*Croton hirtus**		+		+	+				
	Phyllanthus niruri	+	+		+	+	+		+	+
Gramineae	*Brachiaria distachya*				+					
	Dactyloctenium aegyptium					+			(+)	
	Digitaria ciliaris					+				
	*D. fuscescens**	(+)	(+)	+						
	*Echinochloa colonum**					+			+	+
	Eragrostis uniloides	+								+
	Panicum repens				+					
Labiatae	*Hyptis brevipes*	+	+			+				
	*Leucas zeylanica**		+	+		+			+	
Leguminosae	*Desmodium triflorum**	+			+	+				
Melastomaceae	*Sonerila prostrata**		+							
Mimosaceae	*Mimosa pudica**							(+)	+	
Onagraceae	*Ludwigia hyssopifolia**	+	(+)	+	+	+	(+)	+	+	+
Portulacaceae	*Portulaca oleraceae**					+				
Rubiaceae	*Borreria laevicaulis*				+					
	B. latifolia					+		(+)	+	
	*B. setidens**	+		(+)						
	*Hedyotis corymbosa**	+	+	+	+	+				+
Scrophulariaceae	*Lindernia crustacea**	(+)	+	(+)			(+)			+
Solanaceae	*Physalis minima**		+			+	+			
Sterculiaceae	*Melochia corchorifolia**		+	+	+	+	+		+	
Verbenaceae	*Stachytarpheta indica*		+			+	+			

*Host of *Meloidogyne* sp.
(+) denotes main weed/s in field

quent sampling of these fallow plots revealed that the nematode population was again sustained by weeds. In the replanted field at Pauh Sembilan, the tobacco crop was infected by root-knot larvae remaining in the field since the sowing bed and polybag soils were nematode free. At Wakaf Zain and Kg. Telok, infection began in the nursery. As in the previous year's tobacco crop, the root-knot larval population reached a maximum at the third or fourth month after field planting.

In the off-season that followed, all five fields were left fallow. Low *Meloidogyne* populations were detected on weeds surviving after the tobacco crop. The survey at Bachok was terminated with the onset of the monsoonal rains.

The second year's crop in Pasir Puteh district was not adversely affected by the off-season rains in March, and three of the four fields were planted with tobacco *(Table 3)*. The plot at Kg. Kelubi lay fallow. No root-knot larvae were detected in this particular plot (by direct count and bio-assay) throughout the two-year survey, even though suitable weed hosts were present. No *Meloidogyne* infection was observed in the weed roots. In the other fields planted with tobacco, infection of the crop was again found to begin in the nursery (*i.e.*, in the sowing bed and/or in the polybag stage). Pre-plant sampling also showed that larvae were present in some fields. In the off-season that followed, all the fields were left fallow and again, the residual nematode population reverted to their weed hosts as before.

This study shows that root-knot infection of a tobacco crop can start in the nursery bed, polybag or field. Infection in the nursery stage occurs when the farmer inadvertently uses nematode-infested soil, sometimes from nearby plots formerly planted with nematode – susceptible crops such as okra, brinjal or watermelon; or from grassy areas with weeds harbouring the nematode. Even when tobacco plants escape infection in the nursery, transplanting the seedlings to a field previously covered with nematode-infected weeds will bring the tobacco in contact with the larval inoculum. As nematode infection of a tobacco crop can begin in the sowing beds or polybags, it is imperative that suitable control measures be taken in the nursery.

It is suggested that farmers be taught to recognize *Meloidogyne* infection on crops and weeds. Recognition of weeds which are alternate hosts is important since they serve as the link of survival for nematodes in the period between one tobacco crop and the next. Soil from areas where galled roots are found should not be used to make sowing beds or fill polybags. Soil samples can also be sent to relevant agencies to check for the presence of root-knot larvae if such services are available.

With the large percentage of weeds which are hosts to the root-knot nematode in the tobacco-growing districts of Kelantan, natural fallow cannot be recommended for *Meloidogyne* control if the previous crop has been infected. The presence of suitable weed hosts can produce large numbers of root-knot larvae during the fallow period. For example, during the survey, the maximum number of *Meloidogyne* larvae recorded during a fallow period was 520 larvae/200ml soil at Badak *(Table 2)*. The fallow period, however, can be successfully used as a control measure when non-host plants are grown. An example is in Rhodesia where non-susceptible grasses are grown before tobacco to control *M. javanica* (DAULTON, 1963). Similar systems can be worked out in Malaysia.

During the survey, many farmers were observed to leave tobacco plants in the fields after the final reaping instead of removing them as recommended (ANON., 1974). These remaining tobacco hosts enable the *Meloidogyne* females to continue producing eggs and larvae which migrate to neighbouring susceptible weeds. Strict enforcement should be made to ensure that

all farmers uproot, remove and burn all tobacco stalks immediately after the final reaping. This will destroy the potential inoculum of not only nematodes, but other pests and diseases as well. This practice is also a standard recommendation in the U.S.A. where it is applied as soon as possible after the tobacco harvest is completed (POWELL, 1984).

ACKNOWLEDGEMENTS

The authors would like to thank Dr Lee Soo Ann, Fruit Division of MARDI for identification of weed species and to Mr Nor Rijam Ibrahim for his technical assistance.

ABSTRACT

In a two-year study of nine tobacco farms in Bachok and Pasir Puteh, Kelantan, *Meloidogyne incognita* and *M. javanica* were found infecting TAPM 36 variety tobacco. Infection of a tobacco crop could begin in the sowing bed, polybags or field. The nematode larval population reached a peak at the second or third month after field transplanting. During the fallow period after the tobacco crop, root-knot larvae were found to parasitise weeds, of which 23 species were found to be alternate hosts. Weeds tolerant to waterlogging enable the parasite to survive the annual monsoonal floods.

REFERENCES

ABDUL KARIM, S. (1982). Nematod bengkak akar, spesies *Meloidogyne* pada tanaman tembakau. *Teknol. Pert., MARDI* ***3***(2), 162–6.

ANON (1974). Malaysian flue-cured Virginian tobacco manual. Serial No. B.E. 340. National Tobacco Board, Malaysia.

——— (1984). Perangkaan Tembakau Negara. Lembaga Tembakau Negara, Malaysia.

BARKER, K.R. (1985). Sampling nematode communities. In An Advanced Treatise on *Meloidogyne Vol. II : Methodology* (ed. BARKER, K.R., CARTER, C.C. and SASSER, J.N.), pp. 3–17. N. Carolina: N. Carolina State Univ.

BRIDGE, J. and PAGE, S.L.J. (1980). Estimation of root-knot nematode infestation levels on roots using a rating chart. *Trop. Pest Mgmt.* ***26***(3), 296–8.

DAULTON, R.A.C. (1963). Controlling *Meloidogyne javanica* in Southern Rhodesia. *Rhodesia Agric. J.* ***60,*** 150–2.

MANGAT, B.P.S., GUPTA, D.C. and BHATTI, D.S. (1985). Some rabi weeds – new hosts for *Meloidogyne javanica*. *Current Sc., India.* ***54*** (19), 1 006.

POWELL, N.T. (1984). Disease control practices. In *1984 Tobacco Information,* 112 pp. The North Carolina Agricultural Extension Service.

RAABE, R.D. (1963). List of diseases found on the island of Hawaii in 1963. Dept. of Plant Pathology, Univ. of Hawaii *(unpubl.)*

SOUTHEY, J.F. (1970). Laboratory methods for work with plant and soil nematodes. *Tech. Bull. No. 2* Min. of Agric. Fisheries and Food, HMSO, London. 148 pp.

SUNDARARAJU, P., SOSAMMA, V.K. and KOSHY, P.K. (1985). Additional host records of root-knot nematode, *Meloidogyne incognita. Indian J. Nem.* ***14***(2), 183–4.

VALDEZ, R. (1968). Survey, identification and host-parasite relationships of root-knot nematodes occurring in some parts of the Philippines. *Philip. Agric.* ***5***, 802–4.

WHITEHEAD, A.G. and HEMMING, J.R. (1965). A comparision of some quantitative methods of extracting small vermiform nematodes from soil. *Ann. Appl. Biol.* ***55***, 25–38.

Accepted for publication on 19 February 1987.