

Plant parasitic nematode communities associated with the crop banana (*Musa* spp.) at Attappady Tribal hill area, India

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Abstract

Attappady is a region of immense biological importance comes under the Nilgiri Biosphere Reserve area of India at Palakkad district. Biodiversity study of this hill area has great importance in conservative science. Except a national range study for nematode fauna of banana (*Musa* spp.) in Indian banana fields, a detailed survey of this agriculturally and environmentally important area has not reported till now. The diversity analysis of plant parasitic nematodes was done with samples taken from rhizosphere soil and roots of banana at this area. Comparing with the reported nationwide study the present study newly reported the presence of *Aphelenchus* spp., *Dorylaimoides* spp., *Hoplolaimus* spp., *Rotylenchulus* spp., *Tylenchorynchus* spp. and *Tylenchus* spp. from the crop banana other than the already reported one's such as *Helicotylenchus* spp., *Meloidogyne* spp., *Pratylenchus* spp. and *Radopholus* spp. The analysis of nematode genera in different banana cultivars such as *Musa* × *paradisica* L. (AAB) 'Nendran', *Musa acuminata* Colla (AAA) 'Robusta', *Musa acuminata* Colla (AA) 'Kadali' and *Musa* × *paradisica* L. (Mysore AAB) 'Poovan' revealed differences in the reaction to attack between genotypes, and that the cultivar 'Nendran' was the most susceptible one to plant parasitic nematodes.

Keywords: Attappady; banana cultivars; comparison; diversity; nematode

Abbreviations: AAA: triploid cultivar derived from wild cultivar *Musa acuminata* (AA); AA: diploid cultivar derived from wild cultivar *Musa acuminata* (AA); AAB: cultivar derived from wild cultivars *M. acuminata* (AA) and *M. balbisiana* (BB)

Introduction

India is an agriculture country which bears first rank in the world for the production and area of cultivation of several crops including banana (Sheth, 2017). In Indian states, Kerala contributes a major portion to achieve this status of banana. The major share of Kerala's banana was got from the middle district Palakkad and in this Attappady hill area has the lion's contribution (Department of Economics and Statistics, 2017). Most of the regions of Attappady has been covered by forest and comes under the Nilgiri Biosphere Reserve area of India. The specific environmental features of this area altogether contribute climate and became a controlling factor for life cycle of pathogens.

Among the pathogens of banana, plant parasitic nematodes have a crucial role in crop loss by decreased production (Quénéhervé, 1989). Under estimation it affects the banana crop at an average national loss of 21,068.73 million rupees in India (Jain *et al.*, 2007). It results in reduced bunch size, delayed maturation time and reduced tolerance to other stresses (Kibria and Hoque, 2005). It also causes prone to tissue attack by bacteria, fungi and virus (Pinochet and Stover, 1980; Rotimi, 2003). So, evaluation of nematode diversity became very much value addition to the agriculture sector of the state. In the aspect of controlling them it should be started from knowing the diversity and distribution in the banana fields. Except a national range study for nematode fauna in Indian banana fields, a detailed survey at this agriculturally and environmentally important area has not reported yet. So, this study has great importance in conservative science. Thus, the present study focused a systematic survey on plant parasitic nematodes of the crop banana 'Nendran' at the Attappady hill area, Kerala, India. Along with this study, analysis was also carried out for comparing the nematode diversity and nematode population density in different banana cultivars such as 'Nendran' (AAB), 'Robusta' (AAA), 'Kadali' (AA), and 'Poovan' (Mysore AAB) available in this study area.

Materials and Methods

The study area lies in Mannarkkad taluk of Kerala at geographical co-ordinates between 10° 55' 10" and 11° 15' 19" N latitudes and 76° 27' 11" and 76° 48' 8" E longitudes. The altitude varies between 200 and 2400 meters above msl. Map of study area is given in Figure 1.



Figure 1. Map of Mannarkkad taluk in relation to India with indicating the three local self-government areas of Attappady hill area in which samples were taken

Source: <https://mea.gov.in/india-at-glance.html>

Survey and sample collection

Rhizosphere soil samples and root samples of banana were collected by an intensive survey through banana fields of Attappady hill area during the post monsoon season (August to December) of 2017. Thus, nine samples each were collected for both rhizosphere soil and roots for cultivar 'Nendran'. The soil was taken from 30-40 cm away and 25-30 cm deep beneath to the bole of the corm. One rhizosphere soil sample was made by mixing randomly collected three samples from a panchayath. The soil samples were collected and well

packed, labeled in polythene bags. The observed data were arranged based on all three local governing bodies in the study area namely 'panchayaths' such as Agali panchayath, Pudur panchayath and Sholayur panchayath. For comparing the nematode population density between these panchayaths, rhizosphere soil and root samples were collected from the prominently cultivating banana cultivar 'Nendran'.

For comparing susceptibility towards nematodes between different cultivars present in the study area, the selected cultivars were *Musa × paradisiaca* L. (AAB) 'Nendran', *Musa acuminata* Colla (AAA) 'Robusta', *Musa acuminata* Colla (AA) 'Kadali' and *Musa × paradisiaca* L. (Mysore AAB) 'poovan'. Nine samples collected from different banana fields were analysed for the prominently cultivating cultivar 'Nendran'. Based on availability of banana fields in Attappady hill area having at least 100 plants, three samples each were collected for other cultivars for both rhizosphere soil and roots. The cultivar 'Kadali' was collected from field located in Sholayur panchayath, the cultivar 'Robusta' was collected from field located in Pudur panchayath and cultivar 'Poovan (Mysore)' was collected from field located in Agali panchayath.

Extraction of nematodes from soil samples

After reaching the laboratory of KAHM Unity Women's College, Manjeri, samples were used for nematodes extraction. 250 g of rhizosphere soil was taken for Cobb's decanting and sieving method followed by Baermann funnel technique (Southey, 1986).

Extraction of nematodes from root samples

For these the infected root bits were taken from semi hard portion of the main roots. Then they were washed under tap water to remove adhered soil particles. From this 10 g of infected root (fresh weight) were cut into 4 cm sized pieces and macerated gently using kitchen mixer grinder (Panasonic, Japan). Then, these crushed roots were placed over the tissue paper supported with gauge wire net placed in a plastic petri dish. Add some water and left for 16 hours for getting nematode suspension.

Identification and analysis of samples for nematodes

The clear nematode suspensions collected in plastic Petri dish were taken for observing nematodes. 5 ml nematode suspension was taken into three transparent petri dishes after gentle shaking. Then each transparent petri dish with nematode suspension was placed under the camera attached stereo microscope (Magnus MSZ-TR) for observing the nematodes. Photographs were taken for the analysis by using camera attached compound microscope (Olympus CX2Li). Nematodes were identified by using diagrammatic key proposed by Ravichandra (2015). Number and genus of nematodes were recorded and analysed. The measures such as absolute density, absolute frequency and prominence value were taken for comparing the presence of nematode population between different cultivars and three panchayaths. Diversity was assessed based on the number of genera observed at a place. Another measure of severity of attack is done by checking Economic Threshold Level (ETL) ie, one larvae/g soil found, the area was considered as above ETL (Rajendran *et al.*, 1980). The data on prominence value describes the density of a nematode as a factor of absolute frequency and absolute density of nematodes occurred in a region. Absolute Density (AD), Absolute Frequency (AF) and Prominence value (PV) were calculated by using the formula proposed by (Norton, 1978) as follows:

Absolute frequency = Number of samples containing nematodes / Number of samples collected × 100

Absolute density = Number of nematodes in all samples / Number of samples collected × 100

Prominence value = Absolute density × √Absolute frequency

Results

The observations showed that 'Nendran' (AAB) was the most prominently cultivating cultivar in Attappady hill area during 2016-2017. Other cultivars were found in small patches.

Comparison between panchayaths for nematode abundance

Observation of nematodes in banana ('Nendran') found nine different genera of plant parasitic nematodes from rhizosphere soil. The observed genera were *Aphelenchus* spp., *Dorylaimoides* spp., *Helicotylenchus* spp., *Hoplolaimus* spp., *Meloidogyne* spp., *Pratylenchus* spp., *Radopholus* spp., *Rotylenchulus* spp. and *Tylenchorynchus* spp. Six different genera such as *Aphelenchus* spp., *Helicotylenchus* spp., *Hoplolaimus* spp., *Meloidogyne* spp., *Pratylenchus* spp. and *Rotylenchulus* spp. were the nematode genera found in root samples collected from this study area. In collected rhizosphere soil samples, the most frequently occurring plant parasitic nematode genera were *Meloidogyne* spp. and *Rotylenchulus* spp. with 100% absolute frequency. These genera found in all studied panchayaths in both rhizosphere soil samples and root samples. Even though *Rotylenchulus* spp. were found in all panchayaths their frequency of occurrence was not in a level of wide spread at Sholayur panchayath.

Nematode diversity was analysed by observing the number of genera seen at a place. Thus, comparison between all three panchayaths of Attappady hill area revealed that all panchayaths showed five numbers of nematode genera in the soil samples. They are *Aphelenchus* spp., *Dorylaimoides* spp., *Meloidogyne* spp., *Rotylenchulus* spp. and *Tylenchorynchus* spp. in Agali panchayath, *Helicotylenchus* spp., *Meloidogyne* spp., *Pratylenchus* spp., *Radopholus* spp. and *Rotylenchulus* spp. at Pudur panchayath and *Helicotylenchus* spp., *Hoplolaimus* spp., *Meloidogyne* spp., *Pratylenchus* spp. and *Rotylenchulus* spp. at Sholayur panchayath. But in root samples maximum diversity in nematode genera ie, five nematode genera per panchayath was found at Sholayur panchayath only. Among the observed nematode genera *Radopholus* spp. was the least found genus in the rhizosphere soil samples and *Hoplolaimus* spp. was the least found genus in root samples (Table 1). On analysing the soil samples for population density, 43.8% nematodes were found in Agali panchayath followed by Sholayur panchayath (37.79%) and Pudur panchayath (18.41%) (Table 2). Root sample analysis showed the result as maximum population density of more than 50% of nematodes were found at Agali panchayath (50.78%) followed by Sholayur panchayath (29.22%) and Pudur panchayath (20%) (Table 3).

Table 1. Nematode distribution in rhizosphere soil and root of banana 'Nendran' (AAB) samples at Attappady hill area

| Panchayaths | Sample | <i>Aph</i> | <i>Dor</i> | <i>Hel</i> | <i>Hop</i> | <i>Mel</i> | <i>Pra</i> | <i>Rad</i> | <i>Rot</i> | <i>Tyr</i> |
|-------------|--------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Agali | SOIL | +++ | ++ | - | - | +++ | - | - | +++ | +++ |
| | ROOT | +++ | - | - | - | +++ | - | - | +++ | - |
| Pudur | SOIL | - | - | + | - | +++ | + | + | +++ | - |
| | ROOT | - | - | + | - | +++ | - | - | +++ | - |
| Sholayur | SOIL | - | - | +++ | +++ | +++ | +++ | - | +++ | - |
| | ROOT | - | - | +++ | + | +++ | + | - | ++ | - |

- = not recorded; + = present in survey (present only in one observation); ++ = common (present only in two observation); +++ = widespread (occurred in all three observations)

Aph - *Aphelenchus* spp.; *Dor* - *Dorylaimoides* spp.; *Hel* - *Helicotylenchus* spp.; *Hop* - *Hoplolaimus* spp.; *Mel* - *Meloidogyne* spp.; *Pra* - *Pratylenchus* spp.; *Rad* - *Radopholus* spp.; *Rot* - *Rotylenchulus* spp.; *Tyr* - *Tylenchorynchus* spp.

Table 2. Nematode population density in rhizosphere soil samples of banana ‘Nendran’ (AAB) in different panchayaths of Attappady hill area

| Panchayaths | Total nematodes in a Panchayath | Percentage of nematodes in a panchayath | Total number of each nematode genera from all observations | | | | | | | | |
|---------------------|---------------------------------|---|--|------------|------------|------------|-------------|------------|------------|-------------|------------|
| | | | <i>Aph</i> | <i>Dor</i> | <i>Hel</i> | <i>Hop</i> | <i>Mel</i> | <i>Pra</i> | <i>Rad</i> | <i>Ror</i> | <i>Tyr</i> |
| Agali | 364 | 43.8 | 113 (44) | 3 (2) | 0 | 0 | 199 (73) | 0 | 0 | 16 (8) | 33 (13) |
| Pudur | 153 | 18.41 | 0 | 0 | 28 (16) | 0 | 74 (31) | 10 (10) | 2 (2) | 39 (16) | 0 |
| Sholayur | 314 | 37.79 | 0 | 0 | 42 (21) | 23 (10) | 131 (54) | 18 (11) | 0 | 100 (46) | 0 |
| Total of each genus | | | 113 | 3 | 70 | 23 | 404 | 28 | 2 | 155 | 33 |

*Parenthesis (maximum value attained);

Aph – *Aphelenchus* spp.; *Dor* – *Dorylaimoides* spp.; *Hel* – *Helicotylenchus* spp.; *Hop* – *Hoplolaimus* spp.; *Mel* – *Meloidogyne* spp.; *Pra* – *Pratylenchus* spp.; *Rad* – *Radopholus* spp.; *Ror* – *Rotylenchulus* spp.; *Tyr* – *Tylenchorynchus* spp.

Table 3. Nematode population density in root samples of banana ‘Nendran’ (AAB) in different panchayaths of Attappady hill area

| Panchayaths | Total nematodes in a Panchayath | Percentage of nematodes in a panchayath | Total number of each nematode genera from all observations | | | | | |
|---------------------|---------------------------------|---|--|------------|------------|-------------|------------|-------------|
| | | | <i>Aph</i> | <i>Hel</i> | <i>Hop</i> | <i>Mel</i> | <i>Pra</i> | <i>Ror</i> |
| Agali | 358 | 50.78 | 35 (16) | 0 | 0 | 212 (91) | 0 | 111 (45) |
| Pudur | 141 | 20 | 0 | 28 (16) | 0 | 74 (31) | 0 | 39 (16) |
| Sholayur | 206 | 29.22 | 0 | 31 (13) | 3 (3) | 146 (63) | 5 (5) | 21 (17) |
| Total of each genus | | | 35 | 59 | 3 | 432 | 5 | 171 |

*Parenthesis (maximum value attained)

Aph – *Aphelenchus* spp.; *Hel* – *Helicotylenchus* spp.; *Hop* – *Hoplolaimus* spp.; *Mel* – *Meloidogyne* spp.; *Pra* – *Pratylenchus* spp.; *Ror* – *Rotylenchulus* spp.

To know the population abundance of different nematode genera observed in soil samples collected from Attappady hill area they were arranged in the chronological order according to their prominence value. Highest prominence value was achieved by *Meloidogyne* spp. and was followed by *Rotylenchulus* spp., *Aphelenchus* spp., *Helicotylenchus* spp., *Tylenchorynchus* spp., *Pratylenchus* spp., *Hoplolaimus* spp., *Dorylaimoides* spp. and *Radopholus* spp. While arranging different nematode genera observed in root samples, the chronological order according to their prominence value was *Meloidogyne* spp., *Rotylenchulus* spp., *Helicotylenchus* spp., *Aphelenchus* spp., *Pratylenchus* spp. and *Hoplolaimus* spp. Analysis revealed that the banana fields were severely attacked by plant parasitic nematodes. They are in above ETL (Economic Threshold Level) because the maximum number of nematodes found at Agali panchayath and Sholayur panchayath were 364 per 250 g and 314 per 250 g respectively for rhizosphere soil samples. The population density and population abundance of nematodes in each panchayath on cultivar ‘Nendran’ is given in the Tables 4 & 5 for both soil and root samples.

Table 4. Nematode population densities in rhizosphere soil of banana 'Nendran'(AAB) samples at Attappady hill area

| Nematode genera | Nematode occurrence (%) | AF distribution | AD (%) | PV |
|-----------------------------|-------------------------|-----------------|---------|---------|
| <i>Aphelenchus</i> spp. | 13.61 | 33.33 | 1255.56 | 7248.62 |
| <i>Dorylaimoides</i> spp. | 0.36 | 22.22 | 33.33 | 157.11 |
| <i>Helicotylenchus</i> spp. | 8.42 | 55.56 | 777.78 | 5797.46 |
| <i>Hoplolaimus</i> spp. | 2.78 | 33.33 | 255.56 | 1475.4 |
| <i>Meloidogyne</i> spp. | 48.62 | 100 | 4488.89 | 44888.9 |
| <i>Pratylenchus</i> spp. | 3.37 | 44.44 | 311.11 | 2073.96 |
| <i>Radopholus</i> spp. | 0.24 | 11.11 | 22.22 | 74.06 |
| <i>Rotylenchulus</i> spp. | 18.65 | 100 | 1722.22 | 17222.2 |
| <i>Tylenchorynchus</i> spp. | 3.97 | 33.33 | 366.67 | 2116.86 |

*Note - AF = Absolute frequency; AD = Absolute density; PV- Prominence value

Table 5. Nematode population densities in root of banana 'Nendran'(AAB) samples at Attappady hill area

| | Nematode occurrence (%) | AF distribution | AD (%) | PV |
|-----------------------------|-------------------------|-----------------|--------|----------|
| <i>Aphelenchus</i> spp. | 4.96 | 33.33 | 388.89 | 2245.15 |
| <i>Helicotylenchus</i> spp. | 8.37 | 55.56 | 655.56 | 4886.45 |
| <i>Hoplolaimus</i> spp. | 0.43 | 11.11 | 33.33 | 111.09 |
| <i>Meloidogyne</i> spp. | 61.28 | 100 | 4800 | 48000 |
| <i>Pratylenchus</i> spp. | 0.71 | 11.11 | 55.56 | 185.19 |
| <i>Rotylenchulus</i> spp. | 24.26 | 88.89 | 1900 | 17913.48 |

*Note - AF = Absolute frequency; AD = Absolute density; PV = Prominence value

Comparison between different banana cultivars for nematode susceptibility

At the time of comparing different banana cultivars present in Attappady hill area for the presence of nematode population, root analysis was done. From that, the cultivar 'Nendran' was found as most susceptible cultivar found was 'Nendran' and the least susceptible cultivar was 'Poovan (Mysore)'. The root analysis showed that 'Nendran' had a percentage of occurrence of 37.36% while other cultivars such as 'Robusta' had 22.74%, 'Kadali' had 22.1% and 'Poovan' (Mysore) had 17.81%.

The idea about density of plant parasitic nematodes can be observed by knowing the percentage of occurrence of each observed genera in the rhizosphere soil and root samples. In banana cultivar 'Nendran', percentage of occurrence for the observed genera *Meloidogyne* spp., *Rotylenchulus* spp., *Aphelenchus* spp., *Helicotylenchus* spp., *Tylenchorynchus* spp., *Pratylenchus* spp., *Hoplolaimus* spp., *Dorylaimoides* spp. and *Radopholus* spp. were 48.62%, 18.65%, 13.61%, 8.42%, 3.97%, 3.37%, 2.77%, 0.36% and 0.24 respectively. The percentage of occurrence in root samples for the observed genera *Meloidogyne* spp., *Rotylenchulus* spp., *Helicotylenchus* spp., *Aphelenchus* spp., *Pratylenchus* spp. and *Hoplolaimus* spp. were 61.28%, 24.26%, 8.37%, 4.96%, 0.71% and 0.43% respectively. In the rhizosphere soil of 'Kadali', order of percentage of occurrence for the genera *Rotylenchulus* spp., *Meloidogyne* spp., *Dorylaimoides* spp. and *Hoplolaimus* spp. were 46.23%, 24.53%, 19.81% and 9.43% respectively. The chronological order of percentage of occurrence in root samples for the observed genera *Meloidogyne* spp., *Rotylenchulus* spp., *Dorylaimoides* spp. and *Hoplolaimus* spp. were 38.13%, 35.25%, 25.18% and 1.44% respectively.

The rhizosphere soil of 'Robusta' showed percentage of occurrence for the genera in the order of *Dorylaimoides* spp., *Meloidogyne* spp., *Radopholus* spp., *Tylenchus* spp. and *Rotylenchulus* spp. at 30.41%, 26.32%, 23.98%, 10.53% and 8.77% respectively. For the root samples the genera *Meloidogyne* spp., *Rotylenchulus* spp., *Dorylaimoides* spp. and *Radopholus* spp. were occurred at 54.55%, 25.17%, 11.19% and 9.09% respectively. The order of percentage of occurrence for the observed genera in rhizosphere soil sample of 'Poovan (Mysore)' were *Meloidogyne* spp. at 67.37%, *Radopholus* spp. at 18.95% and *Rotylenchulus* spp. at 13.68% and its order in the root samples were *Meloidogyne* spp. at 50.89%, *Rotylenchulus* spp. at 23.21%,

Radopholus spp. at 16.07% and *Dorylaimoides* spp. at 9.82%. For an easy conveyance, occurrence of nematodes in each cultivar in both rhizosphere soil and root were given in the Tables 6 and 7 and Figures 2 and 3.

Table 6. Nematode population densities in rhizosphere soil of different banana cultivars at Attappady hill area

| Cultivar | Nematode genera observed | Occurrence of each genera per cultivar | Mean nematode count | Nematodes in a cultivar (%) |
|-----------------|-----------------------------|--|---------------------|-----------------------------|
| Nendran | <i>Aphelenchus</i> spp. | 13.61 | 92.33±11.55 | 42.68 |
| | <i>Dorylaimoides</i> spp. | 0.36 | | |
| | <i>Helicotylenchus</i> spp. | 8.42 | | |
| | <i>Hoplolaimus</i> spp. | 2.77 | | |
| | <i>Meloidogyne</i> spp. | 48.62 | | |
| | <i>Pratylenchus</i> spp. | 3.37 | | |
| | <i>Radopholus</i> spp. | 0.24 | | |
| | <i>Rotylenchulus</i> spp. | 18.65 | | |
| Kadali | <i>Tylenchorynchus</i> spp. | 3.97 | 35.33±4.84 | 16.33 |
| | <i>Dorylaimoides</i> spp. | 19.81 | | |
| | <i>Hoplolaimus</i> Spp. | 9.43 | | |
| | <i>Meloidogyne</i> spp. | 24.53 | | |
| Robusta | <i>Rotylenchulus</i> spp. | 46.23 | 57±21.08 | 26.35 |
| | <i>Dorylaimoides</i> spp. | 30.41 | | |
| | <i>Meloidogyne</i> spp. | 26.32 | | |
| | <i>Radopholus</i> spp. | 23.98 | | |
| | <i>Rotylenchulus</i> spp. | 8.77 | | |
| Poovan (Mysore) | <i>Tylenchus</i> spp. | 10.53 | 31.67±9.06 | 14.64 |
| | <i>Meloidogyne</i> spp. | 67.37 | | |
| | <i>Radopholus</i> spp. | 18.95 | | |
| | <i>Rotylenchulus</i> spp. | 13.68 | | |

Table 7. Nematode population densities in root of different banana cultivars at Attappady hill area

| Cultivar | Nematode genera observed | Occurrence of each genera per cultivar | Mean nematode count | Nematodes in a cultivar (%) |
|-----------------|-----------------------------|--|---------------------|-----------------------------|
| Nendran | <i>Aphelenchus</i> spp. | 4.96 | 78.33±12.70 | 37.36 |
| | <i>Helicotylenchus</i> spp. | 8.37 | | |
| | <i>Hoplolaimus</i> spp. | 0.43 | | |
| | <i>Meloidogyne</i> spp. | 61.28 | | |
| | <i>Pratylenchus</i> spp. | 0.71 | | |
| | <i>Rotylenchulus</i> spp. | 24.26 | | |
| Kadali | <i>Dorylaimoides</i> spp. | 25.18 | 46.33±8.29 | 22.1 |
| | <i>Hoplolaimus</i> Spp. | 1.44 | | |
| | <i>Meloidogyne</i> spp. | 38.13 | | |
| | <i>Rotylenchulus</i> spp. | 35.25 | | |
| Robusta | <i>Dorylaimoides</i> spp. | 11.19 | 47.67±7.31 | 22.74 |
| | <i>Meloidogyne</i> spp. | 54.55 | | |
| | <i>Radopholus</i> spp. | 9.09 | | |
| | <i>Rotylenchulus</i> spp. | 25.17 | | |
| Poovan (Mysore) | <i>Dorylaimoides</i> spp. | 9.82 | 37.33±6.74 | 17.81 |
| | <i>Meloidogyne</i> spp. | 50.89 | | |
| | <i>Radopholus</i> spp. | 16.07 | | |
| | <i>Rotylenchulus</i> spp. | 23.21 | | |

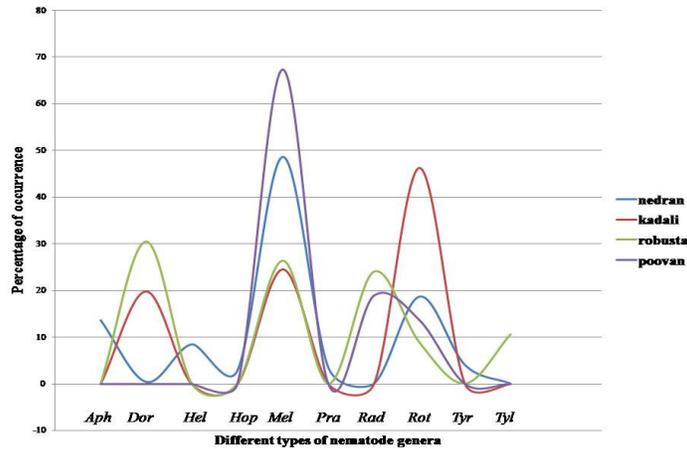


Figure 2. Percentage of occurrence of different plant parasitic nematodes in rhizosphere soil samples from different banana cultivars at Attappady hill area, India

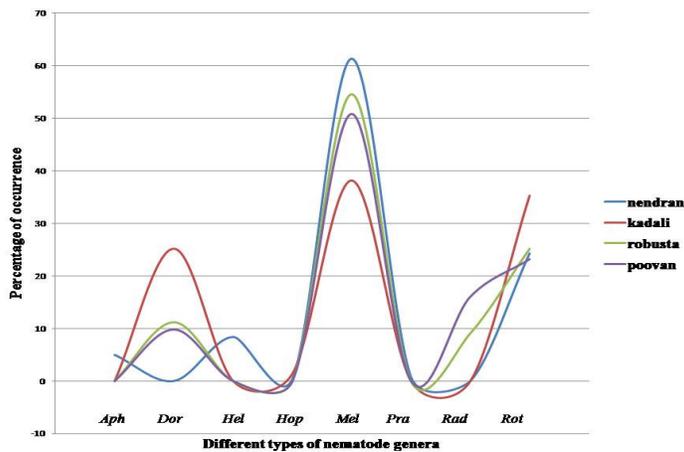


Figure 3. Percentage of occurrence of different plant parasitic nematodes in root samples from different banana cultivars at Attappady hill area, India

The soil analysis of banana cultivars gave the idea that *Meloidogyne* spp. and *Rotylenchulus* spp. were the two genera found in all studied cultivars. Among studied cultivars, genera such as *Aphelenchus* spp., *Helicotylenchus* spp., *Pratylenchus* spp. and *Tylenchorynchus* spp. were found only in ‘Nendran’. An interesting result is that the genus *Tylenchus* spp. was observed only in the rhizosphere soil samples collected from cultivar ‘Robusta’. The genera *Hoplolaimus* spp. was observed in both soil and root samples of the cultivars ‘Nendran’ and ‘Kadali’. Even though *Tylenchorynchus* spp. and *Tylenchus* spp. were present in rhizosphere soil samples, they were not found in any of the root samples. While analysing the root samples, *Dorylaimoides* spp. was observed in all studied cultivars except ‘Nendran’. The major banana attacking nematode *Radopholus* spp. found in all samples except in the cultivar ‘Kadali’ and in root samples of ‘Nendran’.

Discussion

'Nendran' is the most prominently cultivating cultivar in this area. So, the agricultural equipments used by farm employers from one field to another may become a media for field to field transfer of nematodes. Present study revealed that *Aphelenchus* spp., *Helicotylenchus* spp., *Hoplolaimus* spp., *Meloidogyne* spp., *Pratylenchus* spp., *Radopholus* spp., *Rotylenchulus* spp., *Tylenchorynchus* spp., *Tylenchus* spp. and *Dorylaimoides* spp. were the different nematode genera observed in the banana cultivars present in this study area. Ten nematode genera namely *Helicotylenchus*, *Hoplolaimus*, *Macroposthonia*, *Meloidogyne*, *Radopholus*, *Rotylenchulus*, *Pratylenchus*, *Pratylenchus*, *Tylenchorynchus* and *Tylenchus* were isolated from both soil and roots of banana plants from five sampling areas in Peninsular Malaysia (Rahman *et al.*, 2014). The recovery data for nematodes by Kamira *et al.* (2013) from roots and soil of banana in eastern and western D.R. Congo also reported almost same genera such as *Helicotylenchus dihystra*, *H. multincinctus*, *Meloidogyne* spp., *Pratylenchus goodeyi*, *Pratylenchus* spp., *Radopholus similis* and *Rotylenchulus reniformis*. One national range study in India revealed the presence of nematodes associated with banana in Palakkad district were *Radopholus similis*, *Meloidogyne incognita*, *Helicotylenchus multincinctus*, *Heterodera oryzicola* and *Pratylenchus coffeae* (Khan *et al.*, 2010). But the present survey conducted at a small area of Palakkad district itself reported the presence of nematode genera such as *Hoplolaimus* spp., *Rotylenchulus* spp., *Tylenchorynchus* spp., *Tylenchus* spp. and *Dorylaimoides* spp. which were not reported earlier from samples of both root and rhizosphere soil of banana. Roy *et al.* (2014) reported the presence of *R. similis*, *H. multincinctus*, and *P. coffeae* as abundant nematode endoparasites of banana from the Indian state Kerala at a low land area. Some earlier reports showed the wide spread occurrence of *M. incognita*, *R. similis*, and *P. coffeae* in banana plantations (Koshy *et al.*, 1978; Rajendran *et al.*, 1979; Umar and Chubado 2008; Shahzad *et al.*, 2010; Haougui *et al.*, 2011). The study in Nigeria showed that *Meloidogyne* spp. was the most frequently encountered nematode in that region (Okafor *et al.*, 2015). The most distributed nematode genera of *Musa* spp. in the present study area also showed the same information. The genera *Meloidogyne* was the most frequent plant parasitic nematodes in a study conducted at Kenya also (Wachira *et al.*, 2013). Another study on banana nematode population from root samples from all studied eight taluks revealed that *Pratylenchus coffeae* was the predominant species in Thanjavur district (Srinivasan *et al.*, 2011). Rahman *et al.* (2014) showed that *Rotylenchulus* was predominant in the soil samples of banana followed by *Meloidogyne incognita*. At the same time *M. incognita* was found to occur at the highest frequency in root samples and least frequent one is *Tylenchus* in the same study by Rahman *et al.* (2014). But in the present study the situation is reverse. In the present study it was found that *Radopholus* as the least frequent one. Present study results contradicted the conventional perspective (Sheela *et al.*, 1990; Speijer and De Waele, 1997; Araya *et al.*, 2002; Chávez and Araya, 2010) as we found frequency of occurrence of *R. similis* is rather localized instead of widespread as they were expected to be in banana fields. The occurrence of *R. similis* was found in Pudur Panchayath only. The presence of nematode in root sample gave more valid idea. So, the presence of *R. similis* in root sample of 'Poovan (Mysore)' is a noticing information which is not observed in soil sample of this cultivar.

Conclusions

From this study, it is clear that the nematode community is a constraint affecting banana production in Attappady hill area, Kerala, India. Based on the numbers on nematodes present in this agriculture area, it can be placed at above Economic Threshold level. All studied cultivars were found affected. The more susceptible banana cultivar observed in this highly important area was 'Nendran'. It is the more prominent and marketable cultivar. So the lost caused by this pathogen should be addressed and care should be taken in an economical and eco-friendly manner. The least susceptible cultivar was found as 'Poovan (Mysore)'.

Authors' Contributions

The research work (Methodology) was jointly conceived and designed by all three authors (ARU). The work carried out and original manuscript draft preparation was done by the first author (A). The data analysis work and review were done by the third author (U) and preliminary and final proof reading (editing) of the manuscript draft was done by the second author (R). In each step of the research, strict supervision was handled by both second and third authors. The authors cooperated in all the experiments, reading and approval of the final manuscript.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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