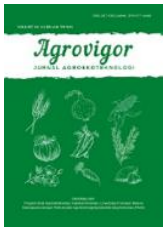
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Article

Nematode Communities in Irrigated and Rainfed Rice Fields in Sukabumi Regency, West Java

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ABSTRACT

Parasitic nematodes are among the most important constraints in rice cultivation, yet information on their community structure in Sukabumi, West Java, remains limited. Understanding nematode ecology in this region is essential to develop sustainable management practices, particularly given the dominance of rice monoculture and the contrasting water management systems between irrigated and rainfed fields. This study aimed to characterize nematode diversity and community composition in both ecosystems and to assess their potential implications for agroecosystem health. Soil and root samples were collected from irrigated and rainfed rice fields, and nematodes were extracted using standard methods before identification to the genus level. Ecological indices were calculated to evaluate community structure. The results revealed relatively low diversity (H′ = 0.71–0.94), low evenness (E = 0.52–0.61), and high dominance (C = 0.42–0.58). Irrigated fields supported a greater number of genera but were strongly dominated by *Meloidogyne*, reflecting the favorable conditions of constant flooding for root-knot nematodes. In contrast, rainfed fields contained fewer taxa but showed marked dominance of *Criconemella*, a genus more tolerant to soil compaction and moisture fluctuations. These differences demonstrate that intensification and water regimes significantly influence nematode assemblages, leading to distinct ecological patterns and potential risks for rice production. Nematode communities in Sukabumi are characterized by low diversity and high dominance of parasitic genera, which may undermine soil health and long-term productivity. Nematodes found in both irrigated and rainfed fields exhibited low diversity, low evenness, and high dominance. The nematodes identified in irrigated rice fields included genus

Helicotylenchus, Rhabditis, Meloidogyne, Hirschmanniella, Tylenchorhynchus, Pratylenchus, and *Aphelenchoides*. Nematodes found in rainfed rice fields included *Meloidogyne, Hirschmanniella*, and *Criconemella*. *Meloidogyne* spp. was one of the dominant nematodes found in both root and soil samples across various rice cultivation types and locations. These findings highlight the urgent need for integrated nematode management strategies, including resistant varieties, organic amendments, crop rotation, and biological control agents, to sustain rice agroecosystems and secure food production in West Java

INTRODUCTION

Rice (*Oryza sativa* L.) is the main food crop for most Indonesians. Rice contains carbohydrates, proteins, vitamins, and fats the body needs (Fitriyah *et al*. 2020). Indonesia is one of the countries with the highest rice consumption in the world. The availability of rice as a staple food must be maintained throughout the year. According to BPS (2023), rice production in 2023 was 53.63 million tons of milled dry grain (MDG), which decreased by 1,12 million tons of MDG compared to rice production in 2022. Sukabumi Regency is one of the regions contributing to national rice production. Rice production in Sukabumi Regency reached 466,836 tons in 2024. This production data shows a 3,11% decrease compared to rice production in 2023 (BPS 2025). The decline in production can be influenced by soil fertility, climate change, fertilizer use, cultivation methods, and attacks of Plant-Disturbing Organisms (Ishaq *et al*. 2016). Rice can be cultivated on both irrigated and rainfed land. Rice productivity in rain-fed paddy fields is generally low due to limited water for rice plant growth. The source of irrigation in rainfed fields depends on rainfall, which is characterized by the absence of permanent irrigation structures. It is located in an area where irrigation is not possible, so rice planting and other seasonal food crops are done once a year (Kementan 2017). Rice cultivation on rainfed land has a high risk. Lack of water supply and nutrient imbalance are the main problems. Most people grow rice in irrigated paddy fields. This is to avoid abiotic stress. Rice plants can be attacked by several pests both in the vegetative and generative phases. One important group of pathogens that attack rice plants is nematodes. Some parasitic nematodes that can attack rice plants include *Hirschmanniella, Meloidogyne* sp., and *Radopholus* sp. (Amir *et al*. 2024). Several reports have shown that *Aphelenchoides besseyi, Ditylenchus angustus, Hirschmanniella oryzae*, and *Meloidogyne* spp. are nematodes attacking rice plants in Indonesia (Sari 2024). An analysis of the nematode community in rice plants on irrigated and rainfed land was conducted to confirm the abundance and diversity of nematodes in the two land types. A comparison between nematode communities in irrigated and rain-fed rice fields in Sukabumi Regency has never been reported. This study aims to analyze the nematode community obtained from irrigated and rainfed rice fields and identify nematodes associated with rice plants in Sukabumi District, West Java.

MATERIALS AND METHODS

Rice Seed Sampling

Sampling was carried out in irrigated rice fields and rainfed land. Samples obtained from irrigated rice fields were root, soil, and seed samples, while rainfed land obtained root, soil, and leaf samples. Sampling followed a diagonal pattern. Rice plants in irrigated rice fields are entering the generative phase, while rice plants in rainfed rice fields are entering the vegetative phase. Sampling was conducted at five points with each point totaling ten clumps.

Nematode Extraction

Soil extraction. Extraction of nematodes from soil using the centrifugation flotation method (Caveness and Jensen 1955). Soil samples were weighed as much as 100 g and mixed with 900 mL of water. The suspension was stirred until homogeneous and precipitated for ± 30 seconds. The suspension was then poured on a stratified sieve with a density of 20, 50, 100, and 400 mesh. Next, the suspension was poured into a 15 mL capacity centrifuge tube. The suspension was centrifuged at 1500 rpm for five minutes, then the water was discarded and the soil sediment was added with 40% sugar solution and stirred until the sugar solution was homogeneous with the soil solution. The suspension was centrifuged at 1700 rpm for one minute. The supernatant was filtered using a 400 mesh sieve and rinsed with running water. The nematode suspension was transferred into a collection bottle.

Root extraction. Extraction of nematodes from the roots using a modified mist chamber method referring to Hooper *et al*. (2005). Roots were cleaned of soil residue, cut into 1-2 cm pieces and weighed as much as 5g. The roots were placed on a funnel lined with a 0.2 cm diameter sieve and put into a mist chamber. The suspension was filtered after 72 hours of fogging with a 400 mesh sieve.

Leaf extraction. Extraction of nematodes from leaves using a modified leaf soaking method refers to Kurniawati *et al*. (2023). A total of 5 g of leaf samples were cut into small pieces and placed on a funnel that had been lined with a 0.2 cm diameter sieve that had been given sterile water until the leaves were submerged. Leaf samples were incubated in a refrigerator at 4°C for 24 hours.

Seed extraction. Based on the International Seed Testing Association (ISTA) standard (2014), 10 g of rice seed samples or equivalent to 400 seeds were cut from the hilum. Extraction of nematodes in rice seeds was carried out using the modified Baermann funnel method. The rice seed pieces were placed on a gauze sieve in a container filled with water. The seed pieces were incubated for 24 hours in a dark place at room temperature (20 °C). The soaked seed pieces were filtered using a 400 mesh sieve.

Preparation of Semipermanent

Preparations Semipermanent preparations were made using Goodey's (1937) modified method, i.e. without using glass woll. A paraffin circle was made on the glass slide using a cork borer of the same thickness. Lactophenol was dripped on the center of the paraffin circle. A total of 2-3 nematodes were placed on the lactophenol solution in an aligned position and covered with a cover glass. The preparation is then heated until the paraffin ring melts and the cover glass adheres to the paraffin. The edges of the cover glass can be glued with clear polish to avoid evaporation.

Nematode Identification Based on Morphological Characteristics

Nematode identification follows standard morphological taxonomy methods using the standard nematode identification reference book "Pictorial Key to Genera of Plant-parasitic Nematodes" (Mai and Lyon 1975).

Analysis of Nematode Communities

Absolute population. Counting was done by counting all nematodes in a 2 mL suspension volume with three repetitions. The nematode population was calculated using the following formula:

$$PA = \frac{\sum_{i=1}^{n} \frac{(p \times V)}{v}}{n}$$

PA = Total nematode population per sample

p = Population of nematode species observed in the counting dish

n = Number of repetitions

V = Volume of nematode suspension at the end of extraction in the sample bottle

v = Volume of nematode suspension in the counting dish

Index of diversity, evenness, and dominance. Analysis of nematode community diversity in each accession was determined using the Shannon-Wiener index with the following formula:

$$H' = Pi\ Ln(Pi)$$

H' = Shannon-Wiener diversity index

ni = number of individuals of nematode type-i

N = total number of individuals of all nematode species

Pi = ni/N

The evenness of the nematode community in the sample was analyzed with the Pielou evenness index (Odum 1998) with the following formula:

$$E = (\frac{H'}{Ln\ (S)})$$

E = Pielou's evenness index

S = number of soil nematode species

The dominance of a nematode community in each accession was analyzed using Simpson's dominance index (Odum 1998) with the following formula:

$C = \sum Pi$

C = Simpson's dominance index

RESULTS AND DISCUSSION

Rice samples were taken from irrigated and rainfed fields in Warungkiara Subdistrict, Sukabumi District (Figure 1). Symptoms of parasitic nematode infestation on rice plants were characterized by uneven plant growth, abnormal-sized roots, puru symptoms on the roots of rice plants, and visually stunted plants (Figure 2). Nematodes that were successfully found on irrigated land included *Helicotylenchus, Rhabditis, Meloidogyne spp., Hirschmanniella, Tylenchorincus, Pratylenchus*, and *Aphelenchoides besseyi*, while on

rainfed land *Meloidogyne* spp., *Hirschmanniella*, and *Criconemella* were found (Table 1).

The calculation of nematode population was done by calculating the absolute population of nematodes in each sample. The absolute population of nematodes from irrigated land soil samples was dominated by the genus *Meloidogyne*, with 37 individuals/100 g of soil, and rainfed land, with 16 individuals/100 g of soil (Table 2). (Table 2). Other nematodes, such as *Criconemella*, were found in rainfed land with 30 individuals/100 g of soil (Table 2). The results of the analysis of nematode populations in each accession were used to analyze the diversity index, evenness index, and dominance index (Table 3). The diversity index of nematodes in root samples was low at the H' index (0.297-0.347), the level of evenness was relatively even (E = 0.45-0.59), and the level of dominance was relatively high (C = 0.400-0.889). The highest nematode diversity index was found in soil sample H' (0.404-0.821), the level of evenness was relatively even (E=0.368-0.592), and the results of the analysis of the dominance level of the root sample showed a high level of dominance (C=0.933-1.00). Meanwhile, the lowest level of diversity was found in the seed sample with H' 0.073 and a very low level of evenness (E=0.000) (Table 3).

Nematodes associated with rice plants on irrigated land included *Meloidogyne* spp., *Helicotylenchus, Rhabditis, Hirschmanniella, Tylenchorinchus, Pratylenchus,* and *Aphelenchoides besseyi* (Table 4), while on rainfed land *Meloidogyne* spp., *Hirschmanniella*, and *Criconemella* were found (Table 5). The absolute population of nematodes found from both types of land showed that the population of nematodes was higher in soil samples. In soil and root samples, nematodes obtained from seed and leaf samples were relatively less than nematodes. Based on the diversity index, nematodes obtained from irrigated and rainfed rice fields in Sukabumi were included in H' ≤ 1 (low diversity). The evenness index showed that nematodes found in rainfed paddy field samples had higher values with values between 0.51-0.75 (fairly evenly distributed). On irrigated land, the evenness index was less evenly distributed. This indicates the presence of a dominant nematode genus in each sample. Nematode diversity decreased with increasing cultivation intensity. This is attributed to physical disturbance, changes in the quantity and quality of organic matter returned to the soil (Yeates & Bongers 1999).

According to Siregar (2024), several nematode genera were found associated with rice plants in Deli Serdang Regency, North Sumatra, including *Hirschmaniella* spp., *Ditylenchus* spp., *Aphelenchoides* spp., *Rotylenchulus* spp., *Trichodorus* spp., *Meloidogyne* spp., and *Xiphinema* spp. The highest nematode population densities found in rice roots were, respectively, those of the *Hirschmaniella* spp. (182.4 individuals), *Ditylenchus* (100.8 individuals), and *Xiphinema* (25 individuals). The highest nematode population densities found in the soil were, respectively, those of the *Hirschmaniella* spp. (82.6 individuals), *Ditylenchus* (48.8 individuals), and *Xiphinema* (15.0 individuals).

Natural vegetation conditions influence the abundance of nematode populations. One of the factors affecting nematode abundance is the content of soil organic matter produced by the overlying vegetation structure. This shows that a high level of vegetation diversity will reduce nematode abundance (Swibawa *et al.* 2015). In addition to the depth of soil taken, the depth of rooting also dramatically affects the nematode population. This is because plant roots secrete exudates recognized by the host, so the exudates spur nematodes to approach and parasitize the host plant (Oktafiyanto & Ibrahim 2021). Rice plants can be attacked by several pests both in the vegetative and generative phases. One important group of pathogens that attack rice plants is nematodes. Some nematodes that can attack rice plants include *Aphelenchoides besseyi, Criconemella, Ditylenchus, Heterodera, Hirschmanniella, Hoplolaimus, Meloidogyne, Paralongidorus, Pratylenchus*, and *Xiphinema* (Luc *et al.* 1995). Several reports have shown the presence of *Aphelenchoides besseyi, Ditylenchus angustus, Hirschmanniella oryzae,* and *Meloidogyne* spp. on rice plants in Indonesia (Machmud & Herman 1991). Parasitic nematodes were also found in rice plants in Terisi Subdistrict, including *Hirschmanniella, Pratylenchus, Helicotylenchus,* and *Meloidogyne* (Sari 2014).

Meloidogyne nematode was found to infect rice crops and became the dominant nematode in rice rice plantations. Symptoms on infected rice plants generally include yellowing, stunted plant growth, wilting, and bullets formed on the roots wilting, and bullets form on the roots (Dutta *et al.* 2012). Several reports state that the NPA species that can attack rice plants include *M. graminicola, M. incognita, M. javanica, M. arenaria, M. oryzae, M. salasi*, and *M. triticozae*. The first report of

nematode infection in rice plants occurred in 2012. Nematode infection in rice plants occurred in 1993 in Yogyakarta and was caused by *M. graminicola*, with a percentage of infection reaching 80% (Erlan 1993).

Hirschmanniella oryzae is the dominant parasite of rice plants after *Meloidogyne* spp. This nematode is about 0.9-4.2 mm long. The sexes are separated, and the lip area is low and horizontal, with rounded edges. In addition, the nematode *Pratylenchus* sp. of the genus Tylenchoidea was also reported in rice. This species is characterized by a body width between 40-160 µm, with a body length between 0.4-0.7 mm, while the body diameter is 20-25 µm. The shape of this nematode is generally elongated, the anterior end of the head is horizontal, with a strong head skeleton (Astuti & Ruslan 2019).

Aphelenchoides besseyi nematode was found in irrigated rice fields from Sukabumi, where seeds can carry it and can survive under anhydrobiosis conditions (Kurniawati & Supramana 2016). This nematode is an ectoparasite and can be transmitted through seeds. Nematodes in the dormant phase in seeds will reactivate when the seeds are planted. Nematodes move through the water layer on the plant surface to the growing points of leaves and stems to obtain nutrients. The optimal temperature for the development of these nematodes is around 21 to 25 ºC and nematodes are reported to survive in dry conditions for 2 to 3 years (Imamah *et al.* 2020). *A. besseyi* infection in rice plants causes symptoms in the form of chlorosis at the top of the plant, drying, and the edges of the leaves look wrinkled and curled (Indriyati 2017). Symptoms can include discolouration of the tip of the leaf to white with a size of 3-5 cm. *A. besseyi* infection can inhibit the activity of the root system so plants cannot absorb water and nutrients in the soil. In general, seeds infected with *A. besseyi* show symptoms in the form of black spots and sunspot symptoms on the surface of the seeds (Lisnawita 2017). Yield losses caused by *A. besseyi* range from 10-50%. However, until now, there have been no reports of yield loss caused by *A. besseyi* in Indonesia (Lubis *et al.* 2019). Yield losses were also reported by several countries, such as China, the United States, and India (Eker *et al.* 2017).

Nematode populations are abundant and widespread in various ecosystems, indicating that nematodes have relatively high adaptability. Water management in rice fields, both irrigated and rain-fed, significantly influences nematode population dynamics. In continuously irrigated rice fields, the constantly flooded soil conditions create an anaerobic environment that is unfavorable for most soil nematodes. This condition reduces nematode activity, mobility, and reproductive capacity, resulting in a relatively low prevalence. Conversely, in rain-fed rice fields or intermittent irrigation systems, the soil experiences alternating wet and dry periods. Better soil aeration during the dry phase supports nematode activity, allowing them to survive, reproduce, and spread infection to rice plants. Therefore, nematode prevalence is generally higher in rain-fed fields compared to those with constant flooding. This is due to morphological variations in the head of the nematode, especially the mouthparts, which allow for variations in food, variations in feeding behaviour, responses to environmental conditions, variations in body size (not significant), and different adaptability. Phytonematodes attack plants in various ways, mainly by water, wind, vectors, plant propagation materials, agricultural tools, and human activities. Nematodes generally favour watery places or moist soils (Soekarto 1997). Most of the nematodes live in the soil. Soil water content is the main ecological factor for nematodes. Otherwise, nematodes will die if the soil lacks oxygen. Nematodes in tropical climates cannot live below 10 ºC, but some nematodes can live at soil temperatures of 50ºC (Tenson *et al.* 1999).

This study aligns with the findings of Yeates & Bongers (1999) that agroecosystem intensification results in a decline in nematode diversity. In continuous monoculture rice cultivation, rhizosphere conditions become relatively homogeneous and tend to favor the dominance of certain nematode groups, particularly plant parasites, while free-living nematode groups such as bacterivores and fungivores decline. Consequently, the nematode community structure becomes simpler, leading to decreased soil ecosystem stability. Furthermore, intensive inorganic fertilization systems accelerate changes in nematode trophic structure. Nitrogen fertilizer application, for example, can increase the population of certain bacteria in the soil, triggering the proliferation of opportunistic bacterivorous nematodes, but in the long term, it shifts the community balance and weakens biological regulatory functions in the soil. This shift indicates that cultivation intensification not only impacts short-term productivity but also has implications for soil health

and the potential for parasitic nematode attacks on rice plants.

The results showed that irrigated rice fields harbored more nematode genera than rainfed fields, but the level of uniformity was relatively low. The consistently moist soil conditions in irrigation systems do support the presence of various nematode groups, but simultaneously encourage the dominance of *Meloidogyne*, which is highly adaptive in water-saturated environments. This strong dominance of a single genus reduces community uniformity despite the greater number of taxa, resulting in a soil ecosystem structure that appears rich but ecologically unbalanced. Conversely, in rainfed fields experiencing moisture fluctuations, fewer taxa were found, but the nematode community was dominated by *Criconemella*. This genus has a better tolerance for dry and compacted soil conditions, allowing it to persist and dominate despite lower interspecific competition. These differences in dominance patterns indicate that environmental characteristics significantly determine the direction of nematode community development: irrigated fields are more susceptible to population explosions of certain parasitic nematodes, such as *Meloidogyne*, while rainfed fields tend to retain specific groups that are adaptive to drought stress. The ecological implication is that the stability of the nematode communities in both ecosystems is equally low, but the pathological risks they pose differ, according to the dominant genera that thrive in each system.

Although several genera of parasitic nematodes have been identified in rice fields in Sukabumi, their pathological relevance to crop yield has not been quantitatively determined. Therefore, the available information is limited to indicating the threat posed by parasitic nematodes, while the extent of nematode populations contribution to reduced rice productivity requires further study by measuring the relationship between infestation levels, field symptoms, and grain yield.

An important implication of this research finding is the need for integrated biological control and management strategies to suppress parasitic nematode populations such as *Meloidogyne graminicola* and *Aphelenchoides besseyi* found in rice fields. To date, no specific recommendations have been discussed, even though the presence of these nematodes has the potential to reduce rice productivity. An Integrated Pest Management (IPM) approach needs to be implemented by combining several methods, including the use of nematode-resistant rice varieties, rotation with non-host crops to break the life cycle, and the addition of soil organic matter that can increase the activity of natural enemies and improve soil structure. Furthermore, the application of biological agents is also promising, for example, *Trichoderma s*pp. which can suppress nematode development through antagonistic mechanisms, and *Pasteuria penetrans* which specifically infects root knot nematodes (*Meloidogyne*). According to Sitanggang (2024), the nematode *Aphelenchoides besseyi* carried through seeds can be eliminated using an ultrasonic cleaner. This elimination technique is up to 100% effective after a 30-minute exposure time. The integration of these various methods not only suppresses the parasitic nematode population, but also maintains the balance of the soil ecosystem so that the sustainability of rice production is guaranteed.

Table 1. Nematodes found in irrigated and rainfed fields in Sukabumi

Nematodes	Land type	
	Irrigated	Rainfed
Helicotylenchus	v	-
Rhabditis	v	-
Meloidogyne spp.	v	v
Hirschmanniella	v	v
Tylenchorhynchus	v	-
Pratylenchus	v	-
Aphelenchoides besseyi	v	-
Criconemella	-	v

* Notes: (v) found and (-) not found

Table 2. Absolute population of nematodes in irrigated and rainfed fields in Sukabumi

Nematodes	Irrigated			Rainfed		
	Root	Soil	Seed	Root	Soil	Leaf
Meloidogyne	0	37	0	10	16	0
Hirschmanniella	35	5	0	0	4	7
Aphelenchoides besseyi	0	0	7	0	0	0
Pratylenchus	4	0	0	0	0	0
Criconemella	0	0	0	0	30	0
Helicotylenchus	0	13	0	0	0	0
Tylenchorhynchus	0	1	0	0	0	0
Rhabditis	4	0	0	1	6	0

Table 3. Diversity, evenness, and dominance indices of nematodes in irrigated and rainfed lands in Sukabumi

Land type	Sample	H'	E	C
Irrigated	Root	0,214	0,133	0,667
Rainfed		0,347	0,500	0,400
Irrigated	Soil	0,619	0,447	0,733
Rainfed		0,821	0,592	0,933
Irrigated	Seed	0,073	0,000	0,267
Rainfed	Leaf	0,181	0,000	0,333

* Notes: (H') Shannon Weaner index, (E) evenness index, (C) Simpson's dominance index

Table 4. Nematodes found in irrigated rice fields in Sukabumi Regency

Sample	Nematodes
Soil	*Meloidogyne* 
	Helicotylenchus 

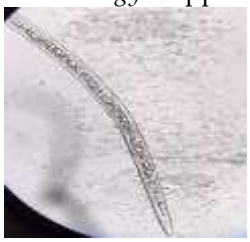
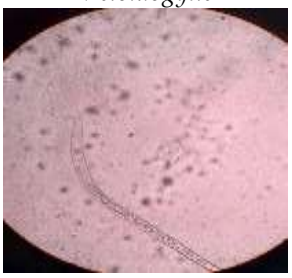
	Hirschmanniella 
Root	*Meloidogyne* spp. 
	Hirschmanniella 
	Rhabditis 
Seed	*Aphelenchoides besseyi* 

Table 5. Nematodes found in rainfed land in Sukabumi Regency

Sample	Nematodes
Soil	*Meloidogyne* 
	Hirschmanniella 
	Criconemella 
	Rhabditis 

Root	*Meloidogyne* spp.	
	Rhabditis	
Leaf	*Hirschmanniella*	



Figure 1. Symptoms on rice plants in Sukabumi irrigated paddy field, a.sample point 1, b. sample point 2, c. sample point 3, d. sample point 4, e. sample point 5, f. root point 2, g. root point 3, h. root point 4, i. root point 5



Figure 2. Symptoms on rice plants in Sukabumi rainfed paddy field, a. sample point 1, b. sample point 2, c. sample point 3, d. sample point 4, e. sample point 5, f. root point 2, g. root point 3, h. root point 4, i. root point 5

CONCLUSION

Nematodes found in both irrigated and rainfed fields exhibited low diversity, low evenness, and high dominance. The nematodes identified in irrigated rice fields included genus *Helicotylenchus, Rhabditis, Meloidogyne, Hirschmanniella, Tylenchorhynchus, Pratylenchus,* and *Aphelenchoides*. Nematodes found in rainfed rice fields included *Meloidogyne, Hirschmanniella*, and *Criconemella*. *Meloidogyne* spp. was one of the dominant nematodes found in both root and soil samples across various rice cultivation types and locations.

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