NEMATODE COMMUNITY CHANGES IN SOIL PLANTED WITH FIVE AGRICULTURAL PLANT TYPES

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NEMATODE COMMUNITY CHANGES IN SOIL PLANTED WITH FIVE AGRICULTURAL PLANT TYPES

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Free living nematodes in the decomposer food web are microfauna responsible for mobilization of soil nutrients. Thus, understanding how their community changes over time provide a better explanation of the soil process dynamic, especially in agroecosystem where plant rotation and polyculture are common. The objective was to investigate the temporal changes of nematode community under various types of agricultural plants including grass, herb, shrub, legume, and tree represented by *Oryza sativa, Amaranthus sp, Solanum lycopersicum, Arachis hypogaea,* and *Citrus reticulata* respectively. These green house experiments consisted of five groups of pots planted with the selected plants, one group of pots with no plant, and another group of all plants. Soils of these plants were sampled from five replicates after one, three, and six months of plant growth. Nematodes were extracted from soil with Baermann funnel method. Soil moisture, pH, total C and N were measured accordingly. Based on genus level, nematode community changed variably depending on plant types. Canonical correspondence analysis revealed a strong correlation between plant types, plant growth, plant age, total CN soil, and nematode genus composition (axis-1: 0.97, axis-2: 0.79, cumulative variance: 86.5%). After one month, nematode community in all treatments was similar to that of no plant soil except shrub and legume. This pattern changed after two months, in which grass, shrub and legume soils showed similar nematode community, whereas all plant soil had a distinct community. At the end of experiments, the community of shrub soil differed from legume soil, but grass and all plants soils showed high similarity. Food web analysis according to nematode functional diversity demonstrated the dominance of fungal decomposition channel (index: 0.78) and indicated 57% detrital Carbon flow at the beginning of experiments. However, after three months, the bacterial decomposition channel dominated (index: 0.62 - 0.95), and suggested an increase in detrital Carbon flow (60 – 90%). The study concluded that plant type, most likely due to growth rate, contributed significantly to soil nematode community development. The changes of nematode genera in soil community were more prominent than that of functional diversity suggesting redundancy function in the ecosystem.

Keywords: plant type, nematode community, decomposition channel, genus level, functional diversity

HỌC VIỆN NÔNG NGHIỆP VIỆT NAM

PHÓ GIÁM ĐỐC
Phạm Văn Cường

1. Introduction

The research was done to answer the question as of how does plant types affect the development of nematode community. Free-living nematodes in the decomposer food web are microfauna responsible for mobilization of soil nutrients [1]. Their position in the soil food web is across the trophic level as bacterivore, fungivore, predator, and omnivore (Figure 1)[2]. Plant feeder or herbivore was not the focus of our research at this time since they do not contribute directly to the decomposition process as of the free-living nematodes.

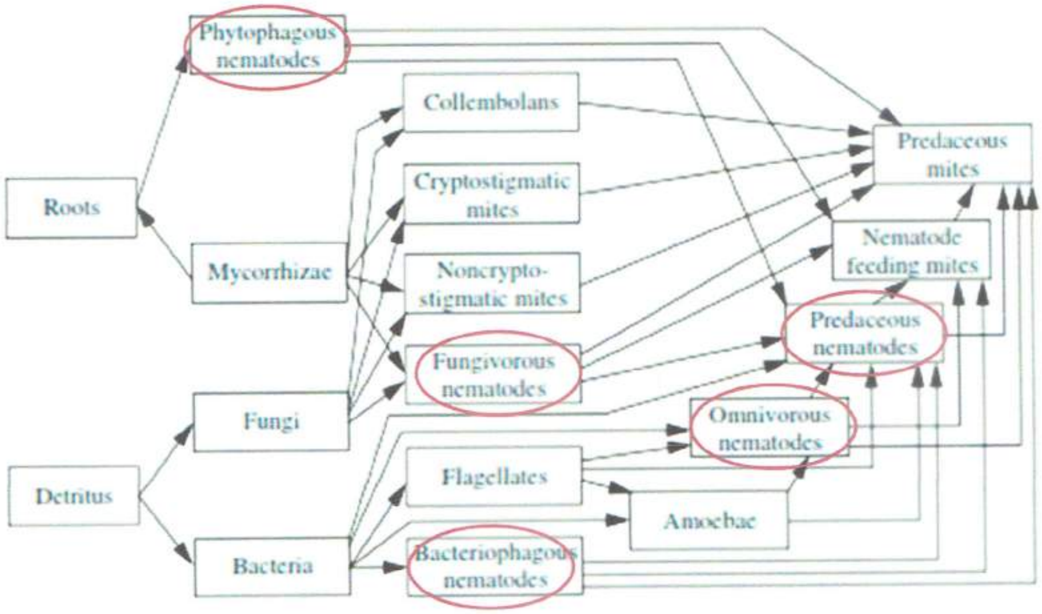

Figure 1. Soil food web showing the nematode position in the web (de Reuter et al., 1995)

The aboveground factors are reported to influence the nematode community. Changes in plant community have shown to change the nematode community through the litter quality they produced [3]. The contribution of plant types, especially agricultural plants, to changes in nematode community over time was less understood. This understanding would provide a better explanation of the soil process dynamic, especially in agroecosystem where plant rotation and poly-culture are common. The objectives were to examine the nematode community respond to changes of the dominant plant type, and to investigate the contribution of the agricultural plant type to nematode community development.

2. Materials and Methods

2.1. *Microcosm Design*

The microcosms were set up in 105 pots of 15-cm diameter. Each pot was filled with soil for 20 cm depth. The soil was collected from a mature forest dominated by *Agathis damara* trees located at Baturraden, Purwokerto, Indonesia. The soil texture was silt loam (60% silt, 22% sand, and 18% clay) with 9.81% Carbon, 0.71% Nitrogen, and pH of 6.85. The forest soil was selected to avoid effect of former agriculture plant and to investigate dominant plant changes. The microcosms were let to sit for six weeks before seed planting to allow recovery for the soil organisms (soil organisms to acclimate/restore) after soil perturbation due to soil handling.

Five types of agricultural plants were selected. This included grass, herb, shrub, legume, and tree represented by *Oryza sativa, Amaranthus sp, Solanum lycopersicum, Arachis hypogaea*, and *Citrus reticulata* respectively. Each plant type was grown from the seed in the microcosms, and made up the five treatments (G: grass, H: herb, S: shrub, L: legume T: tree). Besides, soil with no plant (N) and soil with all plants (A) were assigned as the controls. The microcosms were watered once a day to maintain the water availability for soil biota and plant growth. Wild plants were handpicked and returned to the pots after cutting them into small pieces. There was no external input, such as fertilizers and pesticides, applied to the soil during the experiments.

2.2. *Soil Sampling*

Soil samples from five replicates of the seven treatments were obtained destructively from the microcosms (35 units) after one, three, and six months of growth. This sampling time was set to cover stages of the various plant growths and to follow nematode community after harvest time and plant death. Based on the standard practice in agriculture, *O. sativa* (grass) was commonly harvested after 12-14 weeks, *Amaranthus sp.* (herb) after about 4-5 weeks, *S. lycopersicum* (shrub) after 8-10 weeks, *A. hypogaea* (legume) after approximately 14 weeks, and C. reticulate (tree) took years.

Nematodes as the main soil organism examined in the study were enumerated from each sampling. Soil bacteria were measured as supporting variables to further describe the soil Biology in the microcosm soils. Soil pH, total Carbon, total Nitrogen, moisture, and temperature were, also, measured at each sampling time to describe the physic-chemical properties of the soil.

2.2.1. *Nematode Enumeration*

We applied the modified Baermann funnel technique for extraction of nematode from the soil [4]. The soil sample (15-20 g) was wrapped with paper tissue and submerged in a funnel filled with water. After 24-48 hours, about 5 ml water at the tip of the funnel was collected in a conical tube and preserved with 4% formaldehyde, final solution. Nematodes from each sample were counted and identified at the genus level following Bonger [5], Tarjan [6], Ferris et al. [7], Freckman and Baldwin [8]. The nematodes were further assigned to functional guilds according to Bonger [9], Yeates et al [10] and Ferris et al [11] who separate nematodes into bacterivores (Ba), fungivores (Fu), predators (Pr), omnivores (Om) plant feeders (Pl), and place them into colonizer-persister (c-p) scale (1-5), and particular weight (0.8-5.0) to describe the nematode profiles.

2.2.2. *Bacteria Enumeration and Plant Growth*

The bacteria abundance, extracted from each soil samples, were measured to describe the soil micro-food web. Bacteria are one of the essential basal resources in the micro-food web dominating agriculture soil. They were extracted from the soil and expressed in cfu.g-1 soil. The plant growth was measured following the leaf and stem length every two weeks.

2.3. Data Analysis

Nematode community composition was used to calculate diversity, and food web condition among the plant types. The ecological indices including Shannon diversity (H'), Evenness (E), and Berger-Parker Dominance (D_{BP}) [12]. The food web condition was based on Basal Index (BI), Enrichment Index (EI), Structured Index (SI), and Channel Index (CI) [11]. The indices were calculated as EI = $(100)[e/(e+b)]$, SI = $(100)[s/(s+b)]$, and CI = $(100)[0.8Fu_2/(3.2Ba_1+0.8Fu_2)]$, where $e = \Sigma k_e n_e$, $b = \Sigma k_b n_b$, $s = \Sigma k_s n_s$, the k_s, k_b, k_e = weight of structured, basal, and enriched indicator guilds, n_s, n_b, n_e = abundance of nematodes in the respected guilds, F2 = fungivorous nematodes in c-p scale 2, and B1 = bacterivorous nematode in c-p scale 1 [11]. These food web indices were used to investigate the nematode food web development according to agricultural plant types.

To investigate the genus composition of nematode community under influence of the plant types and how the community changed in relation to plant growth, we performed the Canonical Correspondence Analysis (CCA). We assigned plant types, bacterial abundance, plant growth, soil C, N and pH, soil moisture and temperature as the environmental factors, whereas nematode community, bacteria, ciliate and flagellate abundance as the species variables. The analysis was run in Canoco V.4.5 software.

3. Results

The nematode abundance and the number of genera were similar across the plant types except the soil planted with shrub and legume. The highest abundance was observed in soil with the legume. The nematodes were between 530 and 1400 individuals 100 g-1soil and number of genera ranged from 27 to 36 (Figure 2). The changes in the dominant plant from the soil of *A. damara* (forest soil) to soil with agricultural plants did not change the number of nematode genera significantly. The highest number of nematode genera was in all plant soil (36).

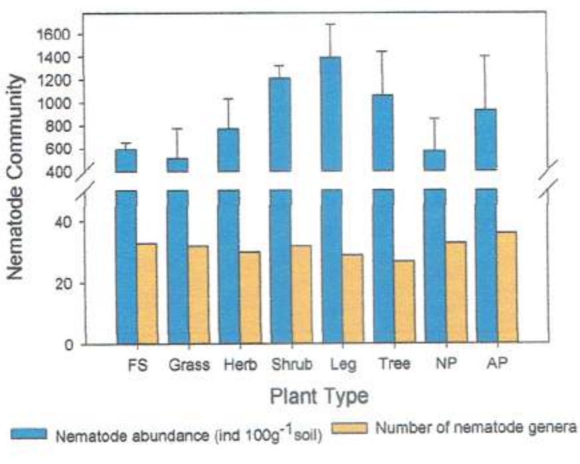

Figure 2. The nematode abundance and number of genera across five agricultural plant types (FS: forest soil, Leg: legume, NP: no plant, AP: all plants, mean ± Standard Deviation)

However, the ecological indices determined by three indices showed a different pattern of the abundance and genus richness across the plant types. Nematodes were more diverse in shrub soil (H': 3.07) than to those of soil of other plant types (H': 2.69 – 2.91). No significant dominance was observed among the nematode genera (E: 0.46 – 0.68). The highest genus dominance was DBP: 0.26 in grass indicating approximately 26% of proportion in the community of grass soil (Figure 3). Changes in plant dominance from trees in the forest to agricultural plants seemed have no effect on the forest soil. It indices was similar to most of the plant types except shrub soil.

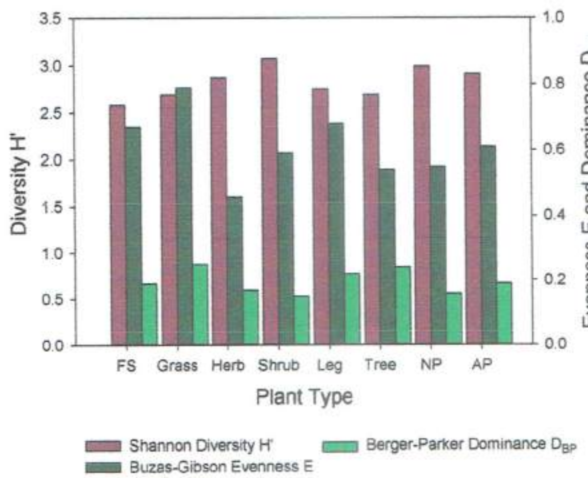

Figure 3. The ecological indices of nematode community across five agricultural plant types (FS: forest soil, Leg: legume, NP: no plant, AP: all plants)

The channel index demonstrated that soil food web of herb soil after three months was dominated by fungal decomposition channel then after six months the fungal channel decreased

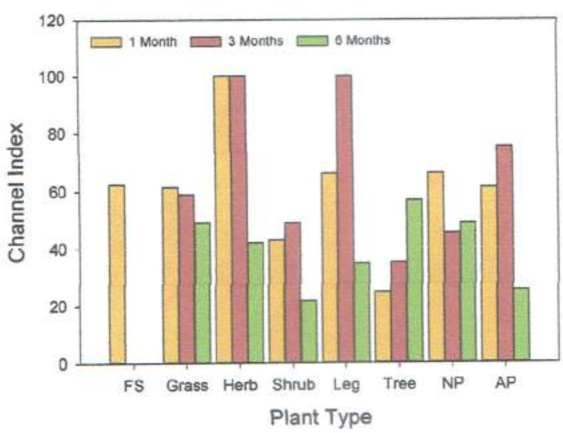

Figure 4. Channel index of nematode community across five agricultural plant types (FS: forest soil, Leg: legume, NP: no plant, AP: all plants)

to 40%. In legume soil, the channel index peaked after three months. Overall, the contribution of fungal channel decreased after six months, except in tree soil. In this plant type, fungal decomposition increased to 60% (Figure 4).

The nematode profile revealed that nematode community developed toward three broad directions after one month. The soil communities of grass, shrub, legume, and all plants appeared to have less linkage in the food web, but after six months they showed to have more linkages. The enrichment index of community in no plant and herb soil decreased after one month but increased after six months. They showed more structure food web after six months. Nematode community of tree soil demonstrated a distinct pattern in which after one month the community had more linkage, and the food web was more structured, but after six months it became less structured (Figure 5).

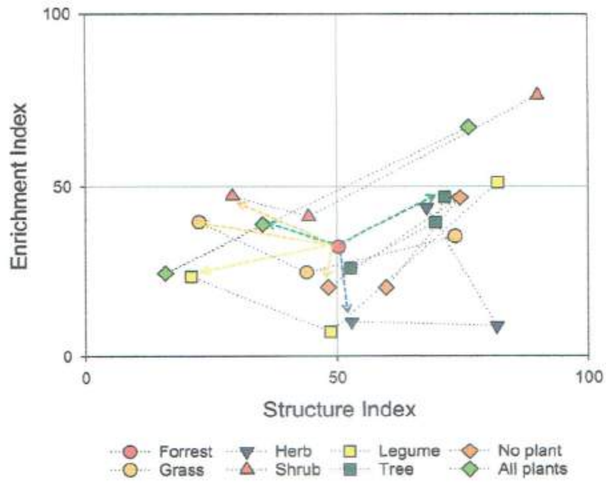

Figure 5. Soil nematode profile across five agricultural plant types.

Figure 6 represented the nematode composition in the community. Three groups of a community were observed after one, three, and six months of plant growth. Soil nematode composition was similar in the herb, tree, and no plant soil after one month of plant growth. Nematodes in shrub and grass soil were similar, and those in legume and all plants were also similar (Figure 6 above). In the next three months of plant growth, three groups of nematode communities were observed but with a different pattern. The soil of herb, tree, and no plant consistently showed similar nematode composition. Shrub, grass, and legume soil had similar nematode composition, whereas all plant soil had a different composition of nematodes (Figure 6 middle). After six months, nematode community of grass, shrub, and legume soil changed. The composition of grass and all plant soil were similar, and those in shrub and legume were also similar (Figure 6 below)

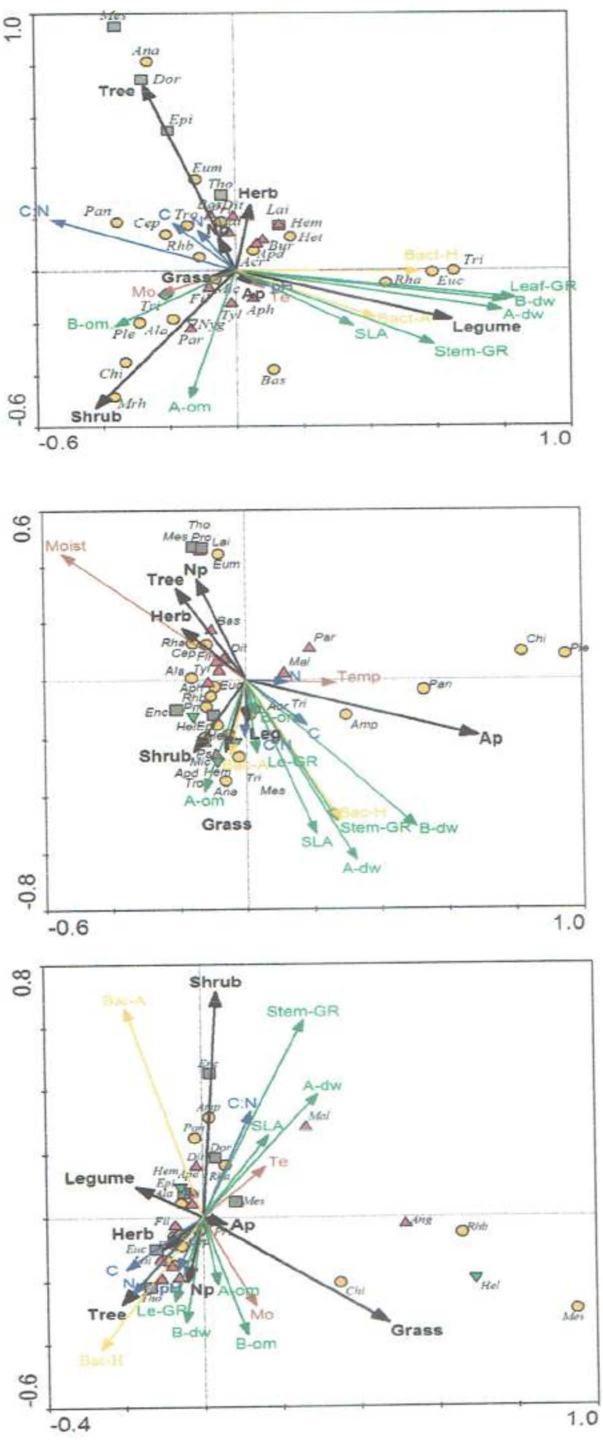

Figure 6. Soil nematode composition according to five agricultural plant types (above: after one month, middle: after three months, below: after six months)

4. Conclusions

Plant type, most likely due to growth rate, contributed significantly to soil nematode community development. The changes of nematode genera in soil community were more prominent than that of functional diversity suggesting redundancy function in the ecosystem.

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