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Soil Macrofauna Abundance in the Intercropping of Mangifera Indica with Aromatic Plants

Iqbal Usamah[1], Lee Yit Leng[2*], Noor Hasyierah Salleh[1], Norawanis Abdul Razak[2], Zarina Zakaria[2], Ras Izzati Ismail[2] and Nur Lailina Makhtar[2]

[1] Faculty of Chemical Engineering & Technology, Universiti Malaysia Perlis, Malaysia
[2] Faculty of Mechanical Engineering & Technology, Universiti Malaysia Perlis, Malaysia

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ABSTRACT

Soil macrofauna such as earthworms, beetles, ants, and centipedes are an important aspect of soil health as they help in the breakdown of plant residue to provide natural resources such as carbon, nitrogen, and phosphorous into the soil. Monocropping practice uses heavy machinery, pesticides, and herbicides to maintain farm productivity, which negatively impacts soil macrofauna abundance. Thus, intercropping is a sustainable practice for farmers to maintain soil health with the minimal use of external input, which can do more harm to the soil ecosystem over a long period of time. The objective of the study is to evaluate the effect of intercropping mango with pandan and lemongrass on soil macrofauna density compared to mango monocrop. The field experiment consisted of mango, mango-pandan intercrops, and mango-lemongrass intercrops. Soil macrofauna was assessed using the tropical soil biology and fertility (TSBF) monolith method. The result showed that intercropping of mango-lemongrass and mango-pandan had higher soil macrofauna density compared with mango monocrop due to the presence of intercrops providing more natural resources and a better soil environment for soil macrofauna to grow and reproduce. However, further long-term research is needed to reinforce these findings.

Keywords: Monocropping, Mango, Earthworm, Lemongrass, Pandan.

1. INTRODUCTION

Mango (*Mangifera indica*) is one of the most demanding crops in tropical and subtropical zones around the world [1]. Malaysia has a tropical climate that undergoes hot and humid weather all year round, making it suitable for a wide variety of tropical fruits to grow, such as mango [2]. There are multiple varieties of mango grown commercially in Malaysia, such as Masmuda. Maha 65, Chok Anan, and Harumanis [2]. Based on the 2017 Malaysia fruit statistic, there were 17,429.7 tonnes of mango from multiple types of varieties, accumulating a revenue of RM 57 million, that were cultivated in the year 2017 [2].

Monocropping is the practice of continuous cropping of the same crop for a long period of time, which is commonly practiced in agriculture with heavy use of mechanization to increase production [3]. However, [3] stated that long-term monocropping has more harm than benefits, such as decreasing the biodiversity and population of soil organisms. Monocropping increases the susceptibility of the plant to pest or disease infestations, and the intensive tillage can disturb the habitat for these soil macrofauna. On the other hand, intercropping is the practice of growing two or more types of crops in the same area concurrently [4]. This practice was found to be more advantageous and sustainable in maintaining soil health without depending heavily on external inputs such as fertilizers and pesticides [5]. Past studies have found that intercropping can also

*Corresponding author: yllee@unimap.edu.my

improve soil macrofauna, such as earthworms and ants, due to the presence of additional crops that promote the recycling of nutrients and provide suitable habitats for the soil organisms to populate [6].

Lemongrass and pandan are aromatic crops that are widely used commercially all over the world and can be grown easily in most soils or environments due to their adaptability and characteristics [7,8]. Pandan tree was found to be beneficial in multiple aspects, such as pest repellent and soil nutrient improvement [9, 10]. Choonharuangdej et al. [11] stated that lemongrass has the ability to inhibit the rate of fungus (*C. Albicans*) infection on other crops due to the presence of secondary metabolites found in the leaf of lemongrass.

Nevertheless, data on the effect of intercropping mango trees with aromatic crops, namely pandan and lemongrass, on soil macrofauna density abundance is lacking. Therefore, the objective of this study is to evaluate the effect of intercropping mango trees with lemongrass and pandan trees on soil macrofauna density, mainly earthworms, centipedes, ants, and beetles. It is hypothesized that mango intercropping with aromatic trees would have a higher density of macrofauna, mainly earthworms, centipedes, ants, and beetles, due to the presence of aromatic crops, which would promote a more suitable habitat for the organisms to grow due to the increase in food source and nutrients from additional aromatic plant residues.

2. LITERATURE REVIEW

Swain et al. [12] found that intercropping of mango-guava-turmeric and mango-guava-mango ginger was found to have lower soil bulk density compared to mango-guava alone due to larger biomass accumulation from mango-guava-turmeric and mango-guava-mango ginger compared to mango-guava alone. Soil macrofauna such as earthworms, ants and termites are important ecosystem engineers that are able to ameliorate soil physical structure and mineral and organic matter composition influencing nutrient flow in soil [13]. Intercropping was found to be beneficial in managing natural resources between living organisms in soil ecosystems due to intercropping would lower competition between species for natural resources due to the presence of additional resources available from intercrop crops [4].

3. MATERIAL AND METHODS

3.1 Experimental site and planting

A field experiment was conducted during the years 2021–2022, in a mango orchard at Chuping, Perlis, Malaysia (6°31'21.9" N, 100°17'08.4" E). The mango trees have been planted for six years. The size of the mango orchard is 941.88 m^2. The mango trees are planted in fine sandy loam soil (Serdang series, Ultisol) at a spacing of 15 m between mango tree rows and 5 m between mango trees in the same row. The aromatic plants intercropped with the mango trees were pandan (Pandanus amaryllifolius) and lemongrass (Cymbopogon flexuosus). The pandan and lemongrass seedlings were obtained from the mature parental plants by vegetative propagation. Each aromatic plant was transplanted at a spacing of 1 × 1 m, with three replications between the mango trees within a row. The field consisted of three types of plots: mango monocrop (T1), mango-pandan intercrop (T2), and mango-lemongrass intercrop (T3), as shown in Figure 1. Approximately, 30 kg of organic fertilizer was applied every 6 months in the mango orchard. The total amount of rainfall received was 1318.38 mm from April 2021 to April 2022.

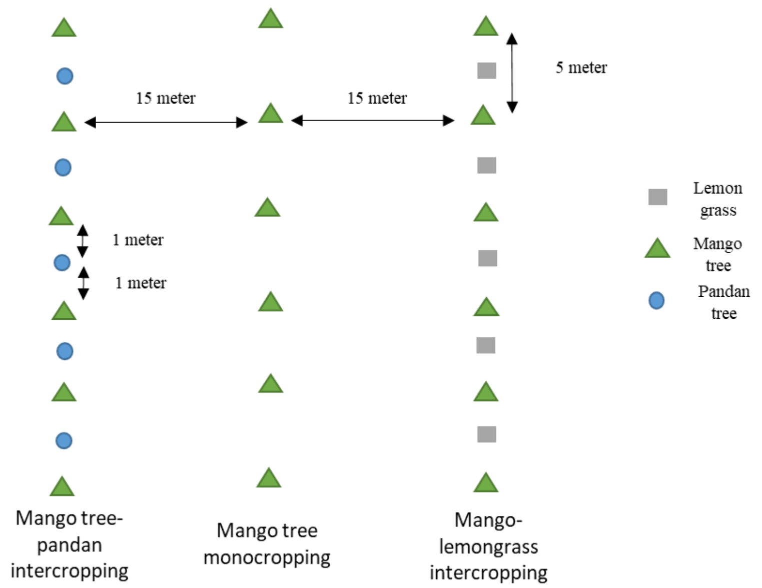

Figure 1: Plot diagram shows field experiment design, including three planting plot. Mango-pandan intercrop, mango monocrop and mango-lemongrass intercrop.

3.2 Soil Bulk Density and Soil Organic Matter Analysis

Soil bulk density was determined using the soil corer method as proposed by [14]. Corers with soil sample was oven-dried at 105◦C for 24 hours. Soil organic matter was determined using the loss of ignition method, where the soil sample was ashed at 550◦C for 8 hours in a furnace [15].

3.3 Soil Macrofauna Analysis

Soil samples were collected randomly for macrofauna analysis after 12 months of intercropping mango and aromatic plants. The macrofauna (earthworms, ants, centipedes, and beetles) was collected by the tropical soil biology and fertility (TSBF) monolith method [16]. A metal quadrat of 25cm × 25cm × 15cm was used, and the soil within the metal quadrat was collected. A soil sample was manually searched for earthworms, ants, centipedes, and beetles. The found specimen was then collected and stored in a 70% alcohol solution prior to counting, as shown in Figure 2.

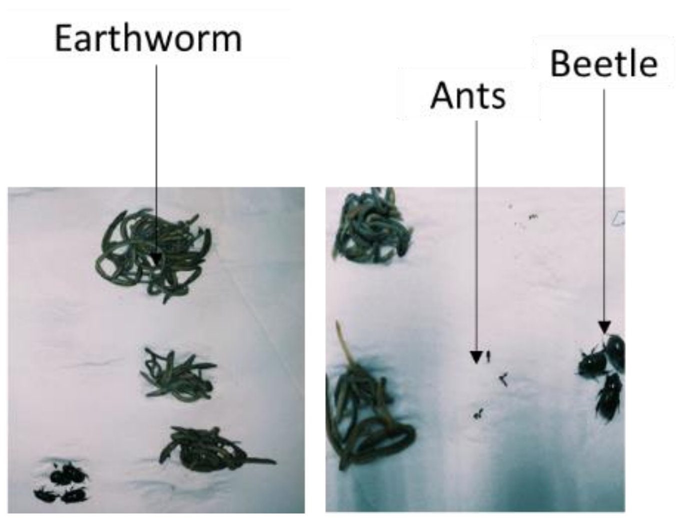

Figure 2: The samples collected from mango monocrop (T1) and identification of soil macrofauna after 12 months of planting.

3.4 Statistical Analysis

Analysis of variance (ANOVA) was used to determine the significant effects of treatments, whereas the treatment means were compared using Tukey's test at $p < 0.05$. The Statistical Analysis System (SAS) software version 9.2 was used for the statistical analysis.

4. RESULTS AND DISCUSSION

4.1 Soil Organic Matter And Soil Bulk Density

In most cases, soil organic matter, bulk density, and farm management are key factors that influence the soil biodiversity and abundance of soil macrofauna [13]. There was no significant difference in soil organic matter across all the treatments at the top soil layer, contradicting the past study (Table 1) [12]. However, intercrop plots (T2, T3) recorded lower soil bulk density compared to mango monocrop (T1) (Table 1). The decrease in soil bulk density promoted better soil aeration and aggregation due to an increase in root biomass in the soil from intercrop crops, promoting better soil physical properties for soil macrofauna density and diversity [12].

Table 1: Effects of different cropping practices on the bulk density and organic matter at the top soil layer. T1 = mango monocropping, T2 = mango-pandan intercropping, and T3 = mango-lemongrass intercropping. Values are means of five replicates followed by ± standard error of means (n = 3).

Plots	Soil bulk density (g cm^{-3})	Soil organic matter (%)
T1	1.69 ± 0.02 A	2.54 ± 0.11 A
T2	1.51 ± 0.02 B	2.26 ± 0.11 A
T3	1.54 ± 0.02 B	2.24 ± 0.14 A

4.2 Soil macrofauna density

Soil macrofauna ranges from 1–2 mm to 20–30 mm in size, including termites, earthworms, insect larvae and myriapods [17]. In addition, soil macrofauna plays an essential role in regulating the soil ecosystem [17,13]. Mango monocrop (T1) recorded the lowest density of earthworms, beetles, centipedes, and ants compared to intercrops (Table 2). Mango-pandan (T2) and mango-lemongrass (T3) intercrop plots recorded no significant difference in earthworm and centipede density. However, T2 recorded the highest ant and beetle density, followed by T3 and T1, which had the lowest ant and beetle density. The findings for earthworms, centipedes, and ants were found to be in accordance with past studies stating that intercropping does improve soil biological diversity and density due to the practice of intercropping promoting the availability of natural resources for the macrofauna and providing suitable habitat for the macrofauna [4]. In addition, the presence of intercrop crop rooting systems promoted a decrease in soil compaction, which directly impacts soil macrofauna, positively providing a looser soil for soil macrofauna such as earthworms to have better mobility in the soil, thus improving their growth rate over time [18].

Table 2: Effects of different cropping practices on soil macrofauna density at the top soil layer. T1 = mango monocropping, T2 = mango-pandan intercropping, and T3 = mango-lemongrass intercropping. Values are means of five replicates followed by ± standard error of means (n = 3).

Plots	Earthworm (*Lumbricina*) ($ind.m^{-2}$)	Beetle (*Apogonia cribricolli*) ($ind.m^{-2}$)	Centipede (*Chilopoda*) ($ind.m^{-2}$)	Ant (*Lasius niger*) ($ind.m^{-2}$)
T1	281.60 ± 11.97 b	22.40 ± 4.16 b	0	25.60 ± 8.16 b
T2	342.40 ± 36.70 a	32.00 ± 5.31 a	19.20 ± 5.99 a	108.80 ± 7.76 a
T3	387.20 ± 15.40 a	28.80 ± 4.33 ab	16.00 ± 5.06 a	67.2 ± 7.83 ab

5. CONCLUSION

The effect of intercropping mango-pandan (T2) and mango-lemongrass (T3) compared to mango monocrop (T1) on soil macrofauna density, mainly earthworm, beetle, centipede and ants was evaluated in this study. Soil sample was collected one year after the intercrop crop was planted and reached maturity. Farming practices such as fertilization are done manually by farmers with fixed value and time for all plots. From the findings, intercrop plots had higher earthworm, beetle, centipede and ants density compared to mango monocrop. T2 and T3 had 21.7% and 37.5% respectively higher earthworm density compared to T1. T2 and T3 had 42.8% and 28.5%, respectively higher beetle density compared to T1. Centipede was found to be present for T2 and T3, while no centipede presence was found for T1. T2 was found to have the highest ants density compared to T1 by four times the T1 value while T2 was also higher than T1 but lower than T3. This was in accordance with past studies stating that the presence of intercrops would improve overall soil biological properties due to the presence of more natural resources for the soil macrofauna and lesser soil compaction, which can be seen from soil bulk density, providing a suitable soil environment for the soil macrofauna to grow and multiply. Further long-term analysis will be needed to reinforce the finding on the effect of intercropping with aromatic trees on soil macrofauna and to analyze which cropping patterns would improve soil biological properties even more.

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