

# Integrated farming system of cattle and oil palm plantation increasing population and diversity of soil fauna in Ultisols soils

*By A Niswati*

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## Preface

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## Preface

The ICSTLM 2020, International Conference on Sustainable Tropical Land Management, is the first international conference on tropical land organized by the Indonesian Center for Agricultural Land Resources Research and Development (ICALRRD) on behalf of the Indonesian Agency for Agricultural Research and Development (IAARD). This first conference was held virtually due to COVID-19 pandemic on September 16-18, 2020, Jakarta time, put the theme of “*Adapting land management to climate change and combating land degradation to increase resilience of agricultural systems*” and invited well-known international experts as speakers in plenary. Moreover, Indonesian Ministry of Agriculture, Dr. Syahrul Yasin Limpo, was show his great attention to this event and pleased to give opening remarks. ICSTLM 2020 can be enjoyed at: <https://seminarbbsdlp.id/icstlm/index.php/en/>.

The conference drew widely concern where around 500 participants per day, coming from 35 research institutions, universities, and government offices based in over 15 countries, were attended in both a plenary and 5 parallel sessions regarding sub-themes: 1) land use, land suitability, and risk mappings – the relationship with agricultural sustainability (LULS), 2) soil, water, and crop management and the socio-economic dimensions (SWCM), 3) adaptation and mitigation to climate change (CC), 4) soil quality assessment: morphological, physical, biological, chemical and geological aspects to support agricultural sustainability (SQA), and 5) digital and precision agriculture (DPA).

More than 200 accepted papers, which carefully screened on the basis of their quality and their relevance to the conference theme, were presented orally in those parallel sessions during three consecutive days using Zoom Breakout Room platform. Presenters, participants, and facilitator were interacted online in each parallel class, while presentation files and Q/A session were managed carefully by Committee. High quality of internet connection, professional members of ICSTLM Committee, and the very cooperative presenters and attendees were the keys of the success of ICSTLM 2020.

All accepted papers were then peer-reviewed by scientific editorial board and reviewers who fit with their expertise. All reviewers have doctoral degree and experience on publishing scientific papers in reputable international journal. Furthermore, ICSTLM Committee took full attention to the plagiarism issue, writing format, and proper layout to guarantee the papers’ quality.

I am gratefully thanked to the editorial board member and the reviewers for pouring their valuable time and advice to meet the quality of papers. Thank also to authors for presenting their work at conference, considering the reviewers’ suggestion for improving their papers’ quality, and for publishing in this volume. My sincere appreciation to Indonesian Ministry of Agriculture, all ICSTLM Committee, facilitators, co-organizer, and all other participants for their support in ICSTLM 2020.

December 2020

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## Peer review declaration

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## Peer review declaration for ICSTLM 2020

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All papers published in this volume of IOP Conference Series: Earth and Environmental Science have been peer reviewed through processes administered by the Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

- **Type of peer review:**

- *We used triple-blind peer review, author and reviewer identities are hidden to each other, and also from the Editor(s). Author(s)'s name in each paper was replaced with ID number. We also used ID number for each reviewer.*

- **Describe criteria used by Reviewers when accepting/declining papers. Was there the opportunity to resubmit articles after revisions?**

- *We used 12 important aspects to be considered during evaluation. Scoring was applied to each point to decide whether a submission is accepted or rejected, as follow:*

POINTS OF ATTENTION	N	YN	Y	Score
Is the title well chosen (explaining the content, yet not too long)?				
Is the abstract well written and properly structured (justification/ urgency, objectives, methods, results, conclusions) and does it summarize the most important aspects of the paper?				
Is the overall structure of the paper clear and appropriate (introduction, methods, results, discussion, conclusion)?				
Does the introduction clearly identify the underlying problem in the context of the present knowledge in this domain? Does it clearly state the aim(s) of the paper?				
Does the author acknowledge related published research by others?				
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If the paper is based on a statistical analysis, is this performed in the correct way? Is the sampling unbiased and sufficiently large?				
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Does the conclusion outline the meaning of the main findings and answer the objectives?				
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and correctly formatted? Are the cited items publicly accessible (although not necessarily for free)?				
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- *Yes, all articles reviewed and revised by the author(s) have the opportunity to resubmit only through ICSTLM website address according to time schedule.*
- **Conference submission management system:**
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- **Number of submissions received:**
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- **Number of submissions sent for review:**
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- **Average number of reviews per paper:**
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  - *We accepted 78% of 273 submitted papers to ICSTLM 2020. We tracked the institution of all authors of accepted papers, ensuring they are researchers. Almost all of them have had experience to publish scientific articles in national and/or international publications. We ensure they deserved to publish internationally through IOP Publishing.*
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## 3 Integrated farming system of cattle and oil palm plantation increasing population and diversity of soil fauna in Ultisols soils

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**Abstract.** Integrated farming system is an agricultural practice that must be done for sustainable agriculture. The objectives of the research were to compare the population and diversity of soil meso fauna in the oil palm plantations applying with integrated farming system of cattle and oil palm plantation (IFSCO) and without IFSCO (non-IFSCO) in Ultisols soil. The research was conducted in two oil palm plantations, i.e. oil palm plantation with IFSCO (5 ha) and without IFSCO (non-IFSCO) (5 ha) applications which were located in the Karya Makmur Village, Tulang Bawang District, Lampung, Indonesia. The research was arranged using surveys and with systematic methods for sampling soil, earthworm, and mesofauna. Population of earthworm and soil mesofauna were enumerated by hand sorting methods and trapped with Barlese-Tullgreen funnel, respectively. The results showed that the application of IFSCO had a higher population and biomass of earthworm as well as abundance and diversity of soil mesofauna than that non-IFSCO. There are two types of dominant earthworms and 12 species of mesofauna in IFSCO soil, and 9 species in that of non-IFSCO. Several physical and chemical properties of soils are positively correlated with the presence of these soil fauna.

### 1. Introduction

Intensive agricultural practice for food and energy consumption<sup>21</sup> continued to increase following population growth. This phenomenon caused the degradation of the physical, chemical, and biological properties of soil. Therefore, efforts to improve and maintain soil quality (especially the biological quality) are needed for the long term to achieve sustainable agriculture. On the other hand, farmers always depend on the use of chemical fertilizers to sustain their agricultural productions although an excessive use of chemical without adding any organic fertilizers would increase land degradation and other negative impacts [1,2]. Therefore, the application of organic fertilizers is very necessary to maintain soil quality. One of the *in situ* organic fertilizers that can be applied to farmers' land is cow manure.

One of the agricultural systems<sup>3</sup> that can benefit both (physically and chemically) and socio-economically for farmers is the integrated farming system of cattle and oil palm plantation (IFSCO)



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[3]. In this system, its extent effect on the soil biological properties has not yet been investigated clearly and certainly what extent the effect. A few research revealed related to the benefits of cattle-crop integration with palm oil plantation. The study is limited to soil fauna as decomposers of organic matter [4], their abundance due to long-term mulching practices in sugarcane plantation [5], or long-term tillage system and nitrogen fertilizer in the crop rotation of legume – cereal [6,7].

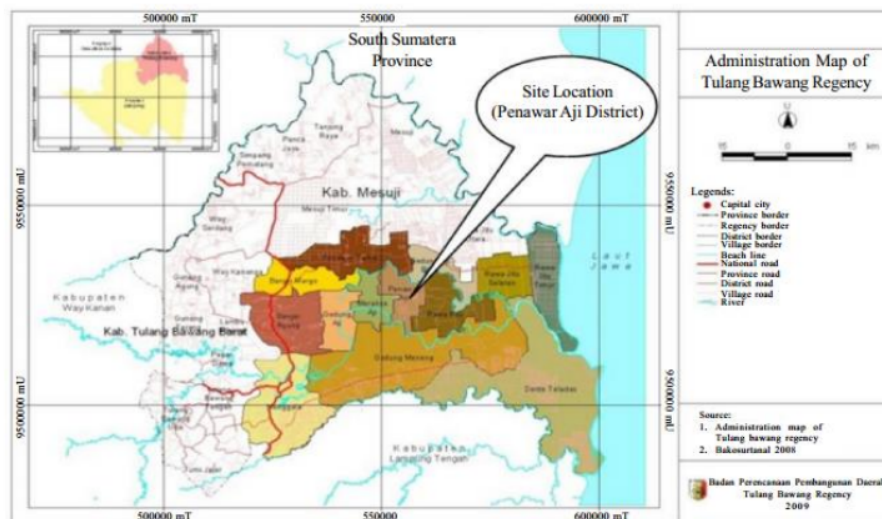
Soil fauna including earthworms and soil mesofauna are very important to be used as a bioindicator of soil fertility [8]. They provide beneficial services *in situ*, as well as to the surrounding environment. For example, soil fauna can increase agricultural production by enhancing soil drainage creating passages for plant roots, aerating the soil, and recycling organic matter and nutrients [9]. Earthworms play key role as decomposers in terrestrial ecosystems [10]. Differences in tillage, nutrient inputs, and crop rotation can influence the population and species composition of earthworm communities [11]. Earthworm and soil mesofauna are simple and easy to measure and therefore suitable for assessing soil degradation [12].

The purpose of this study was to compare the abundance of soil fauna especially earthworm and soil mesofauna at oil palm plantation applied with IFSCO and without IFSCO (non-IFSCO) at Tulangbawang District, Lampung Province.

## 2. Materials and methods

### 2.1. Study site

The field study was conducted from June to September 2016 at the area for the cattle farming development at Tulang Bawang District, Lampung Province, Indonesia. Oil palm plantation applied with IFSCO and a conventional oil palm plantation (without or non-IFSCO) applications. The map of the study site is presented in figure 1.



**Figure 1.** The map of the study location [3].

### 2.2. Experimental setup

The study was conducted using surveys and systematic sampling methods to collect soil samples. In each field, the soil samples were taken systematically from 10 spots (with 5 replications), with the distance between one spot to another spot was 60-100 m in the area of 5 ha. The IFSCO has been applied for more than 1.5 years at 4 years old of oil palm and 5 years of age for non-IFSCO. The IFSCO treatment was fertilized with cattle-based organic fertilizer (10 kg plant<sup>-1</sup> or 1.25 Mg ha<sup>-1</sup>)

produced from Organic Fertilizer Processing Unit, dolomite (1 kg plant<sup>-1</sup> or 125 kg ha<sup>-1</sup>), and inorganic fertilizers (Urea, SP-36, and KCl of 100, 50 and 50 kg ha<sup>-1</sup>). The fertilizers were applied once a year. On the other hand, in the field without the IFSCO application, the oil palm plants were not fertilized with organic but only fertilized with inorganic fertilizers, i.e. Urea, SP-36, and KCl of 150, 75, and 75 kg ha<sup>-1</sup> for each application. The inorganic fertilizers were applied twice a year.

### 2.3. Earthworm enumeration

Earthworms were sampled by *in situ* hand sorting methods by making monolith with an area of 50 cm × 50 cm from topsoil down to 30 cm soil depth for every spot [13] with ten replications. The abundance of earthworms was counted one by one. Cocoon was counted as one individual earthworm. The soil was returned to the hole after sampling. After counting the total population, the fresh earthworms collected were washed in water, dried, weighed, and then preserved in 70% ethanol. The main variables observed were earthworm population and biomass.

### 2.4. Soil mesofauna enumeration

Sample for mesofauna was taking by core samples in each spot and extracted with modified Berlese-Tullgren methods [14]. The identification and quantification of soil mesofauna were carried out up to the order-suborder levels by using a LEICA EZ4 HD compound microscope. Before identification, the soil mesofauna were preserved on 70% ethanol. The main variables observed were soil mesofauna abundance and Shannon-Wiener diversity index and Simpson dominance indexes.

### 2.5. Data analysis

The data analysis was performed by comparing the earthworm and soil mesofauna field data (with and without IFSCO applications). Furthermore, a statistical data analysis was performed using t-test using Minitab 16 software.

## 3. Results and discussion

### 3.1. Earthworm population, biomass, and diversity

Table 1 shows the population and biomass of earthworm in IFSCO and non-IFSCO applications. The application of organic fertilizer on IFSCO plantation has a significant effect on the population and biomass of earthworms. The average earthworm population in the IFSCO was 74 individuals m<sup>-2</sup> with average earthworm biomass of 37.3 g m<sup>-2</sup>. Very contradictory condition occurred in the non-IFSCO field in which there was no earthworm population.

**Table 1.** Population, biomass of earthworms and soil temperature in two different management of oil palm plantation.

Field	Earthworm population (individuals m <sup>-2</sup> )	Earthworm biomass (g m <sup>-2</sup> )	Soil temperature (°C)
IFSCO	74	37.3	29.49
Non- IFSCO	0	0	30.85

Soil temperature is also correlated with population and biomass of earthworm where its value was higher in non-IFSCO application than that in IFSCO, namely 30.85 and 29.49°C, respectively. Temperature is considered the most important environmental factor for earthworm activity [15]. In this research location, the organic carbon content in IFSCO was higher than that in non-IFSCO, 3.99 ± 0.63 and 2.90 ± 0.88% [3]. Soil organic matter which derives from composting animal manure (often from cattle) can serve as food for the earthworm. A high population of earthworms was also found in two and a half years after the first organic matter application. The farmyard manure and cattle slurry treatments contained the largest number of earthworms (about 800–900 individuals m<sup>-2</sup>), while the unamended controls had the lowest earthworm abundance (about 150 individuals m<sup>-2</sup>) [16].

The absence of earthworm populations in the non-IFSCO field was presumably due to the absence of additional organic matter into the soil since the first-time oil palm plantations were built at this are. The non-IFSCO field was never added with organic fertilizer. Several researchers reported that the decrease of soil organic matter in the long term will reduce the earthworm population caused by earthworms leave or die [17,18] because the condition is not suitable for earthworm habitat. The quality and nature of organic material are one of the conditions determining the reproduction and growth of earthworms.

**Table 2.** Results of earthworm identification at the IFSCO field.

Position of the clitellum (segments to)	Form of prostomium	Type of setae	Percentage of individual (%)
12	Zygotobous	Lumbricine (widely-paired)	35.3
7	Zygotobous	Lumbricine (widely-paired)	5.9
8	Zygotobous	Lumbricine (widely-paired)	5.9
12	Epilobous 2	Lumbricine (widely-paired)	11.8
13	Zygotobous	Lumbricine (widely-paired)	5.9
7	Zygotobous	Lumbricine (distant-paired)	5.9
12	Zygotobous	Lumbricine (distant-paired)	17.6
13	Zygotobous	Lumbricine (distant-paired)	5.9
12	Epilobous 2	Lumbricine (distant-paired)	5.9

There were 9 earthworm types found in IFSCO field with proportion presented in table 2. Based on position of the clitellum, mouth type, and setae, the earthworms found in the IFSCO site were classified into *Lumbricus* sp. This earthworm body is characterized by flat shaped, colors (of bright brown to reddish purple the dorsal part), creamy belly, and yellowish tail), the number of segments of 90–195, the clitellum position at 7-12<sup>th</sup> segments, and 8 setae per segment. The male and female genital holes are located in the 14<sup>th</sup> and 13<sup>th</sup> segments.

### 3.2. Abundance and diversity of soil meso fauna

Table 3 shows the abundance of soil mesofauna in the IFSCO and non-IFSCO fields. The mesofauna at IFSCO field showed higher values and more diversified than that at the non-IFSCO field. Fourteen orders, suborders, and genera were recorded in this study.

There were 12 mesofauna species, i.e. *Oribatida*, *Prostigmata*, *Mesostigmata*, *Collembola*, *Astigmata*, *Lepidoptera*, *Hymenoptera*, *Diplura*, *Pseudoscorpio*, *Spider*, *Coleoptera* (family *Staphylinidae*), and *Coleoptera* (family *Curculionidae*), found in the IFSCO field, and 9 species, i.e. *Oribatida*, *Collembola*, *Coleoptera* (family *Staphylinidae*), *Mesostigmata*, *Prostigmata*, *Isoptera*, *Spider*, and *Coleoptera* (family *Carabidae*) in the non-IFSCO. The most dominant mesofauna in both fields were *Acarina* order, i.e. *Oribatida*, *Prostigmata*, and *Mesostigmata*, then followed by the *Collembola* order. These results were following the study of various types of organic matter affecting the increasing mesofauna [19].

Table 2 shows 7 order-suborders of mesofauna in both land types being *Oribatida*, *Mesostigmata*, *Prostigmata*, *Collembola*, *Coleoptera* (family *Staphylinidae*), *Hymenoptera*, and *Spider*. This means that the types of mesofauna found in IFSCO and non-IFSCO fields are the same due to environmental conditions, namely soil temperature, soil acidity, and soil moisture, although qualitatively it is still better in the IFSCO field [3]. The environmental conditions in the two land types are not extreme, so there are still many types of soil mesofauna that are tolerant of these environmental conditions. Probably, the availability of organic matter is the main limiting factor for the mesofauna population presence in the non-IFSCO field. This is supported by research which shows that soil fauna in organic farming is higher than that in conventional farming [20].

**Table 3.** The abundance of soil mesofauna in two different management of oil palm plantation.

Soil mesofauna	IFSCO field (individuals dm <sup>-3</sup> )	Non-IFSCO field (individuals dm <sup>-3</sup> )
1. <i>Oribatida - Acari</i>	43	5
2. <i>Prostigmata - Acari</i>	14	1
3. <i>Mesostigmata - Acari</i>	12	1
4. <i>Collembola</i>	12	2
5. <i>Astigmata - Acari</i>	5	0
6. <i>Lepidoptera</i>	2	0
7. <i>Hymenoptera</i>	2	1
8. <i>Diplura</i>	1	0
9. <i>Pseudoscorpio</i>	1	0
10. <i>Spider</i>	1	1
11. <i>Coleoptera (1)</i>	1	0
12. <i>Coleoptera (2)</i>	1	2
13. <i>Coleoptera (3)</i>	0	1
14. <i>Isoptera</i>	0	1
Average	94	13

The results also show that 5 species of mesofauna were highest in the IFSCO field, i.e. *Oribatida* (43 individuals dm<sup>-3</sup>), then followed by *Prostigmata* (14 individuals dm<sup>-3</sup>), *Mesostigmata* (12 individuals dm<sup>-3</sup>), *Collembola* (12 individuals dm<sup>-3</sup>), and *Astigmata* (5 individuals dm<sup>-3</sup>). *Oribatida*, *Prostigmata*, *Mesostigmata*, and *Astigmata* constituted *Acarina* sub order so that the dominant mesofauna in the IFSCO field were *Acarina* and *Collembola* orders. Several studies reported that soil mesofauna was dominated by mites (*Acarina*) and springtails (*Collembola*), which are among the most abundant and widespread soil arthropods in most soils [21, 22]. Because of their abundance, species richness, and almost ubiquitous presence in soils, mites and springtails have been proposed as soil quality indicators. This study also proved that the mesofauna in agricultural soils were dominated by *Acarina* and *Collembola*.

The abundance of soil mesofauna in the IFSCO field is due to the presence of a lot of organic matter (organic-C 3.90% in IFSCO and 2.99% in non-IFSCO) [3] which is a source of food and environmental conditions. The soil moisture content, temperature, and humidity in the IFSCO field are better than that in the non-IFSCO field. The role of *Oribatida* in the decomposition of organic matter is influenced by environmental factors. Other research showed an oil palm plantation area in the Bajubang sub-district, Batanghari, Jambi, that the abundance and diversity of *Oribatida* are significantly higher in the soil with litter than in soil with live plants [23]. Likewise, with *Acarina* that it is abundant in soil with organic debris and usually exceeds than other *Arthropods* [24].

**Table 4.** Mean value of soil mesofauna abundance and diversity indexes, and dominancy index in the IFSCO and non-IFSCO field.

Observation variable	Mean value		Statistical test	
	IFSCO	non-IFSCO	P-value	T-value
Soil mesofauna (individuals dm <sup>-3</sup> )	94 ± 68.9	13 ± 12.2	0.002*	3.43
Diversity index (H')	1.26 ± 0.29	0.63 ± 0.60	0.008*	-3.45
Dominancy index (C)	0.34 ± 0.08	0.24 ± 0.23	0.203	-2.80

\*significantly different at 5% significance level. Number after ± is standard deviation.

Based on table 4, the results of the T-test have shown that the abundance and diversity indexes of mesofauna in the IFSCO field were significantly different from the non-IFSCO field. This shows that

the application of organic fertilizers on the IFSCO field has a significant effect on the survival of the soil mesofauna so that their population and also diversity level in the IFSCO field are higher and greater than those in the non-IFSCO field.

The dominance value of mesofauna in the IFSCO field was not significantly different from that in non-IFSCO field ( $P > 0.05$ ) (table 4). However, the average value of the dominance index in the IFSCO field is higher than that in the non-IFSCO field. Based on the criteria for the Simpson Dominance Index [25], the Dominance Indexes on IFSCO and non-IFSCO fields are low ( $C < 0.5$ ), meaning that were no biota dominated both IFSCO and non-IFSCO fields. This is probably because the species of mesofauna that live in the IFSCO and non-IFSCO fields are almost the same and are not predators of each other

#### 4. Conclusions

The population and biomass of earthworms as well as their abundance and biodiversity of soil mesofauna are higher in the land with an integrated farming system of cattle and oil palm plantation compared to that in conventional management. The application of this agricultural system can be recommended to lead to sustainable agriculture.

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