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To cite this article: A Niswati *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **215** 012034

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To cite this article: 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **215** 011002

IOP Conf. Series: Earth and Environmental Science **215** (2018) 011002 doi:10.1088/1755-1315/215/1/011002

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International Conference on Organic Agriculture in the Tropics: State of the Art, Challenges and Opportunities

To cite this article: 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **215** 011001

International Conference on Organic Agriculture in the Tropics: State-of-the-Art, Challenges and Opportunities

August 20-24th, 2017

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IOP Conf. Series: Earth and Environmental Science **215** (2018) 012034 doi:10.1088/1755-1315/215/1/012034

Long-term organic mulching and no-tillage practice increase population and biomass of earthworm in sugarcane plantation

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Abstract. This research aimed to study the effect of no-tillage and bagasse mulching on the population and biomass of earthworm in sugarcane plantation for six years application. The experiment was conducted in 2010 (plant cane, 1st period); the first sampling in July 2011; plant cane, period in August 2014 and the last in August 2016 (ratoon 1, 2nd period) at sugarcane plantation in Sumatra, Indonesia. The treatments were soil tillage as the main plot i.e. (conventional tillage and no-tillage) and bagasse mulch as the sub-plot i.e. 80 mg bagasse ha^{-1}yr^{-1} in 2010–2014 and 70 mg bagasse ha^{-1} in 2015, and with no bagasse mulch. The results showed that in the first sampling, from July 2011 to July 2013, all treatments did not significantly affect earthworm population and biomass. On ratoon 3rd, application of bagasse mulching started to show a significant effect on it, in which revealing significantly higher of earthworm population and biomass than that in without bagasse mulch. In 2015–2016, the effect of bagasse mulching on earthworm population was more pronounce than that in control treatment. Treatment of no-tillage after six years application gave higher population of earthworm than that of conventional tillage after six year application.

1. Introduction

Landuse changes from forest to intensive agriculture have been practiced since 1970s in Lampung Province, Indonesia [1] by developing monoculture plantations and agro-industrial estates, which cause the decrease in the biodiversity [2]. The loss of biodiversity by intensification of agricultural practices is a major environmental issue that calls for the design of new cropping systems.

Gradually, the no-tillage (NT) practice has been increasingly adopted by Indonesian farmers [3].Conventional tillage (CT) causes subsoil compaction and decreases earthworm number as well as quality of soil [4]. Continuous application of CT in a monoculture system of sugarcane plantation may accelerate soil degradation by decreasing soil organic matter [5]. Various system of tillage have been changed density and community composition of soil organisms [6].Therefore it is necessary to formulate a superior and sustainable land preparation system. In organic farming, NT practice have been proved to increase earthworm population [7], in which earthworm is an excellent indicator of soil biodiversity and fertility.

Organic mulching have been reported to increase Soil Organic Matter (SOM) [8] and increase population and biomass earthworm [9]. In sugarcane plantations, bagasse (sugarcane fibers from which the juice has been extracted) is often ignored even though they have higher fiber with high carbon content. Application of bagasse mulching in sugarcane plantation may improve soil quality because of increase in soil organic matter.

Earthworms play important role in soil and represent a large proportion of soil organism biomass and have important agro-ecological functions since they influence organic matter dynamics and soil structure [10]. Earthworms may be used as bioindicators of soil management because they are easy classify and are very sensitive to both chemical and physicalsoil parameters [11].

The aim of this study was to study effect of long-term no-tillage and conventional tillage with and without bagasse mulching on the changes in population and biomass of earthworm in sugarcane plantation.

2. Materials and Methods

2.1. Study site
The field study was conducted at a sugarcane plantation (altitude c.a. 45 m) in Sumatra, Indonesia, from September 2010 to August 2016. The experimental site was located within a large area (approximately 25,000 ha) of the plantation and on Ultisols soil [12].

2.2. Experimental setup
The study was conducted in a split plot design with soil tillage as the main factor and bagasse mulch as a secondary factor. The treatments were no-tillage without mulch (NT), no-tillage with mulch (NT + M), conventional tillage without mulch (CT), and conventional tillage with mulch (CT + M) repeated across five replicate blocks. Each plot was 25 m × 25 m with a 5-m buffer zone adjacent to the road. The conventional tillage treatment plots were ploughed three times to depths of 20 cm (first), 40 cm (second) and 20 cm (third) in July 2010. Sugarcane seed stems were planted on July, 2010.In the mulch treatment, 80 $t{\cdot}ha^{-1}$ (wet weight) of bagasse mulch were spread on the soil surface in the first plant cane (August 2010) and on an every ratoon (1st, 2nd and 3rd ratoon). In the second plant cane (September 2014), 80 $t{\cdot}ha^{-1}$(wet weight) and in the 1st ratoon 70 $t{\cdot}ha^{-1}$bagasse mulch were spread on in soil surface. Eighty tons (wet weight) per hectare of organic bagasse + filter cake (blotong) + ash (BBA) mixture, consisting of five parts Bagasse, three parts blotong (filter cake) and three parts bagasse ash, were spread prior to ploughing in the CT and CTM plots and after planting in NT and NTM plots. Inorganic fertilizers (N:P:K 120:80:180 $kg{\cdot}ha^{-1}$) were applied in all treatments at the time of planting. Herbicides were not applied to any of the treatments in the first plant cane but it applied in the second plant cane.

2.3. Earthworm enumeration
Earthworms were collected by handsorting methods (50 cm × 50 cm) from top soil down to 30 cm depth of soil for every plot. Followed by mustard (7%) extraction from the same holes [13]. Every sugarcane plantation seasons, we sampled at least two time on March and July (before harvesting). Observation of earthworm were conducted from July 2011 (first harvest) to August 2016 (after harvestingthe second plant cane, first ratoon).

The abundance of earthworm were counted one by one. Cocoon was counted as one individual earthworm. After counting total population, the fresh earthworms collected were washed in water and were weighed and then preserved in 70% ethanol.

2.4. Soil sampling
Soilsamples were taken for analysis of soil carbon content because of treatment. Sampling were conducted every years around vegetative maximum of sugarplant until harvest time. Soil samples were

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collected from 12 sites of auger sampling in one plot and they were mixedto obtain a composite soil sample.

2.5. Data analysis
Data were tabulated and plotted from year to year. On the 2016, data were tested for significant differences in population and biomass of the earthworms by a two way split plot ANOVA-procedure and Least Significance Different test with a tillage as the main factors and bagasse mulching as a secondary factors were used. For statistical analysis Excel softwarewas used. Correlation analysis were used to study relationship between soil organic carbon, bulk density, soil temperature and soil water content.

3. Results and Discussion

3.1. Earthworm population
The figure 1 shows the changes in earthworm population during six year of sugarcane plantation with tillage and mulch treatment. In the 2011–2012, earthworm populations were no differences among treatments. Since 2013, it showed application of bagasse mulch increased earthworm population both in CT and NT. However, after second periods of plant cane (2015), the earthworm population decreased comparing to the third ratoon in the first plant cane, although NT+M exhibited a tendency higher than that of in the other treatments. In the last observation (1st ratoon, second periods plantcane), the effect of bagasse mulch was significantly higher than no bagasse mulch, both in CT and NT. It might be because of increase in soil organic carbon by continuous application of bagasse mulch (table 4). Furthermore bagasse mulch as crop residue mulch could keep soil humidity and soil temperature more stable. Temperature and soil moisture are considered the most important environmental factors determining earthworm activity [14].

Table 1 and table 2 showthat the earthworm population exhibited statistically significantly higher in plot with bagasse mulch both in December 2015 and May 2016, however, there were no significantly different on tillage system and interaction between tillage and mulching.

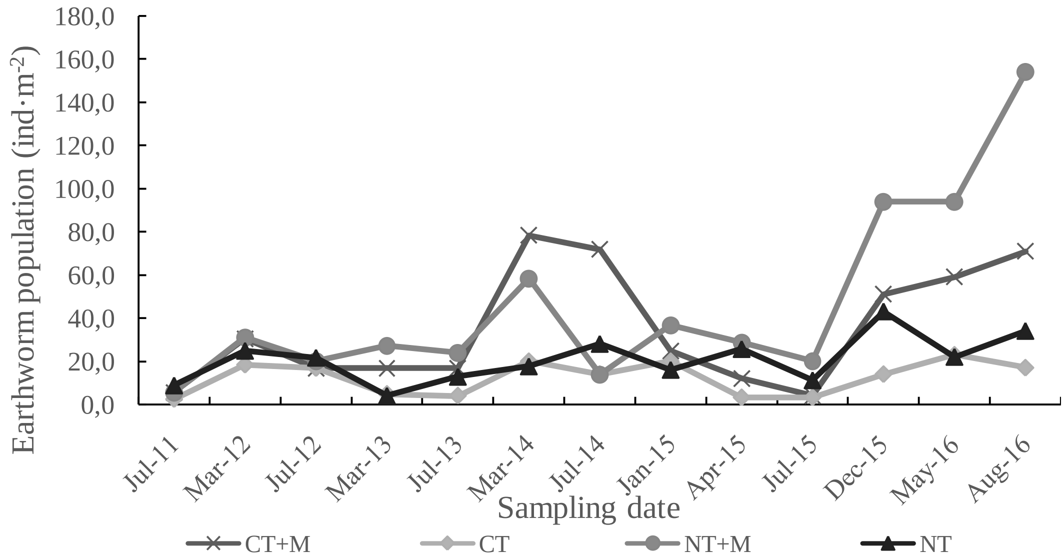

Figure 1. The changes in earthworm population during six year of sugarcane plantation with tillage and mulch treatment.

3.2. Earthworm biomass

Figure 2 shows the fluctuation of earthworm biomass during sugarcane plantation. Application of bagasse mulch both in NT and CT resulted the higher biomass than that of in treatment without bagasse mulch. The higher of biomass was also resulted by the bigger size and higher weight of individual earthworm. It was due to a substrate and the environment for earthworm living more suitable with bagasse mulch. This results also indicated that bagasse mulch is suitable for improving soil biodiversity. There was no significant effect of treatment when the samples were collected in December 15 and May 16 (the first ratoon, the second periods) (table 1 and 3).

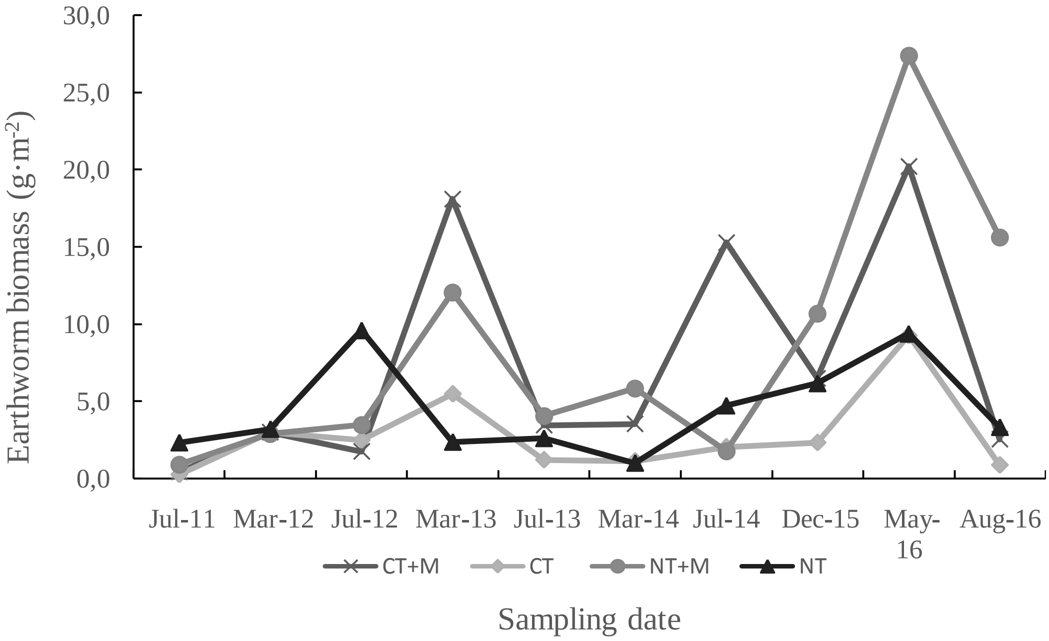

Figure 2. The changes in earthworm biomass during six year of sugarcane plantation with tillage and mulch treatment.

Table 1. Earthworm population and biomass in the first ratoon of the second period.

Treatments	December 2015		May 2016	
	Population (ind·m^{-2})	Biomassa (g·m^{-2})	Population (ind·m^{-2})	Biomassa (g·m^{-2})
NT	43± 34.57	6.16± 6.19	22± 12.84	9.84± 8.46
NT+M	94± 64.47	10.68± 5.73	94± 61.88	38.39± 20.59
CT	14± 8.29	2.32± 2.30	23± 8. 67	15.18± 14.75
CT+M	51± 26.74	6.50 ± 3.03	59± 36.27	20.85± 15.39
ANOVA	F - value			
Tillage (T)	4.09^{tn}	3.87^{tn}	0.61^{tn}	0.54^{tn}
Bagasse mulch (M)	6.96*	4.18^{tn}	29.48**	6.08*
T×M	0.004^{tn}	0.01^{tn}	2.52^{tn}	2.72^{tn}

Table 2. Effect of bagasse mulching on earthworm population after six year application in sugarcane plantation.

Treatments	Earthworm population (ind·m^{-2})	
	December 2015	May 2016
No-bagasse mulch	28.4 (4.76) a	22.8 (4.75) a
With Bagasse mulch	72.4 (8.11) b	76.4 (8.44) b
LSD 5%	2.93	0.77

Note: Data followed by the same letter are not significantly different by LSD test (p<0.05).
Value in parentheses indicatesthe value after data transformation with($\sqrt{x+1}$).

Table 3. Effect of bagasse mulching on earthworm biomass after six year application in sugarcane plantation.

Treatment	Earthworm population (ind·m^{-2})	
	December 2015	May 2016
No-bagasse mulch	4.24 a	12.51 a
With Bagasse mulch	8.59 a	29.62 b
LSD 5 %	4.90	15.99

Note: Data followed by the same letter are not significantly different by LSD test (p<0.05)

Table 4. Changes in soil organic carbon after longterm of after reduce tillage and bagasse mulch.

Treatments	Soil Organic-C (%)				
	July 2011	July 2012	July 2013	July 2014	May 2015
NT	1.04±0.08	1.09±0.15	1.26± 0.03	1.32±0.03	1.31± 0.08
NT+M	0.86±0.20	1.18±0.08	1.32± 0.08	1.48± 0.08	1.60± 0.20
CT	1.09±0.18	0.92±0.17	1.07± 0.13	1.14±0.03	0.96± 0.10
CT+M	1.00±0.08	1.12±0.15	1.10± 0.13	1.30±0.07	1.23± 0.14

3.3. Correlation between soil organic carbon, bulk density and earthworm population

Figure 1 and figure 2 show relationship between soil organic carbon, bulk density and earthworm population, respectively. There were a positive correlation between soil organic carbon and earthworm population, but a negative correlation obtained in bulk density and earthworm population. It was estimated that soil organic carbon content closely related to earthworm population. The higher carbon content resulted the higher earthworm population. In the other hand, the higher soil bulk density resulted the lower earthworm population. This results indicated that soil poresare formed by earthworm. Longterm tillage practice had been made soil compaction and decreased earthworm in Hungary [4].

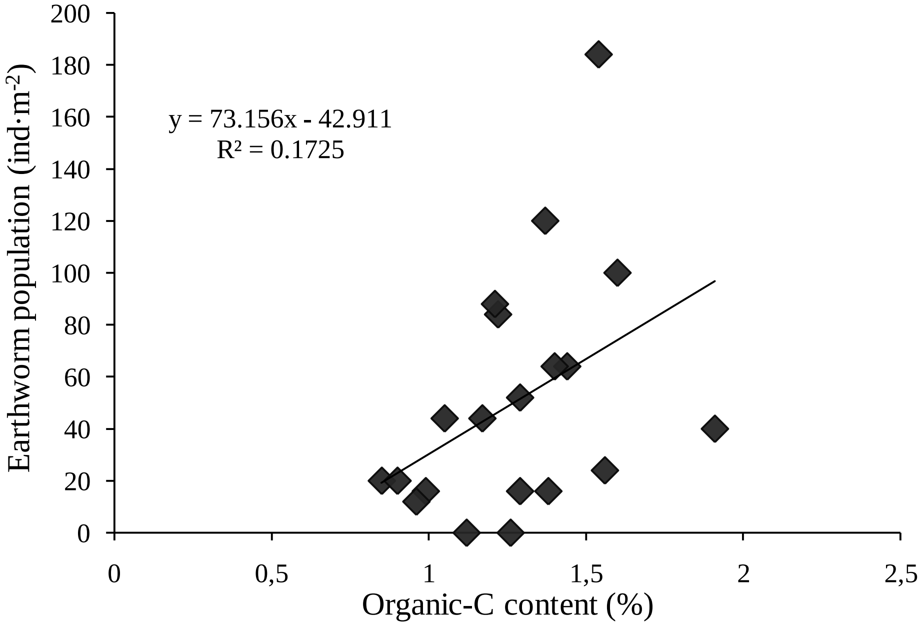

Figure 3. Correlation between soil organic-C content and earthworm population.

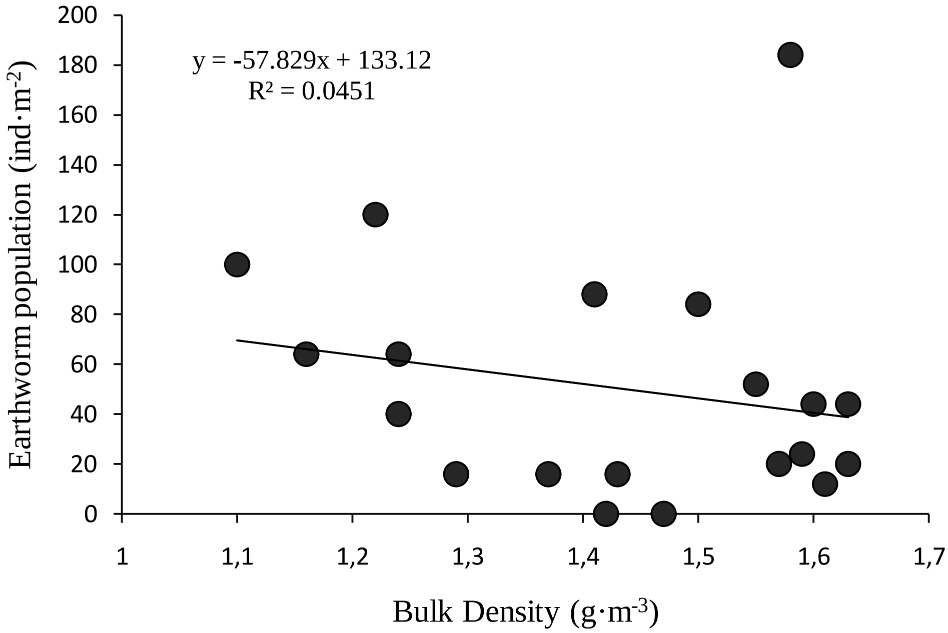

Figure 4. Correlation between soil bulk density and earthworm population.

4. Conclusion

The application of bagasse mulch increases earthworm population and biomass. The conventional tillage with bagasse mulch are recommendedto stabilize high earthworm population. The application of bagasse mulch increases soil organic carbon and soil bulk density, but decreases the earthworm population and biomass. Therefore mulch treatment in combination with no-tillage is an effective residue management to improve soil quality.

Acknowledgement
The authors sincerely thank to the staff at the GunungMadu Plantation and Yokohama National University for the financial support for this research.

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