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Amendment of Soil Physical and Biological Properties Using Rice Husk and Tapioca Wastes

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Abstract

A field experiment in a pineapple plantation at Lampung Province of Indonesia was conducted for 15 months to investigate the effect of rice husk and tapioca wastes (cassava bagasse and cassava peel) used as organic amendments, on soil physical and biological properties. The treatments included control, rice husk mulch, cassava bagasse mulch, cassava peel mulch, cassava peel-soil mixture and black polyethylene film mulch. The organic materials were applied manually at a rate of 30 kg m^{-2}. The soil physical and biological properties at the initial and final stages of the experiment were measured and compared. The results showed that the moderate rate of rice husk's decomposition process slightly increased SOM of surface layer that may had led to somewhat decreased particle density and available water content enhancement. On the other hand, cassava bagasse mulch decomposed within very short period after application and thus its roles especially in soil physical properties were no more noticeable in 15 months after its application. Due to the slow decomposition rate, 15 months was probably too short for cassava peel to contribute in SOM enhancement as well as other soil physical properties. However, the application of investigated organic materials for soil amendment resulted in the more abundance earthworm populations, bulk density decreasing, and the increases of macro pores and WSA in general. The existence of earthworms in the soil is certainly contributed positive effects in the soil properties, especially physical soil properties. But which soil properties that were most affected by the earthworm activities cannot be concluded, since other factors such as soil microorganisms could also play a role in promoting soil properties enhancement.

Key words : Indonesia, soil organic matter, *Red-Yellow Podzolic,* organic mulch, tapioca wastes, earthworm

1. Introduction

Soil deterioration is an important problem in pineapple plantation areas, such as Indonesia, due to the long period of pineapple life cycle and the tropical monsoon climate. The first harvest time could take about 15 to 18 months from seedlings, and optimum production could still be obtained at the third harvest time, which could take about three years. Long culture period, high annual rainfall and high mean temperature all year long in tropical monsoon climatic countries result in decreasing of soil physical, chemical and biological properties.

Erenstein (2003) stated that soil degradation process could be arrested by the application of organic mulching. Organic mulching also gradually improves the soil physical and biological properties. Crop residues have also been widely used for organic mulching studies. Straw mulches contributed organic matter to the soil, hence increasing infiltration and reducing mechanical impedance (Tindall *et al.,* 1991). Furthermore, Lal *et al.* (1980) showed that applying 1.2 kg m^{-2} straw mulch was effective in suppressing soil erosion up to 0% after deforestation. Application of plant residues as mulch in the tropics is known to improve the soil microclimate, besides providing food for earthworms (Tian *et al.,* 1993). Many studies have shown the importance of worm activity to soil productivity and thereby to plant growth.

Organic mulching materials could be obtained not only from the crop residues of postharvest, but also from the waste of agricultural industries. For example, cassava peel and cassava bagasse wastes are generated in the tapioca industries during tapioca production process. Generally, in the tapioca production, 1,000 kg of cassava would produce about 200 kg tapioca and almost 800 kg solid wastes (Trade and Industry Dept. of Indonesia, 2003). Meanwhile, the area for cassava cultivation in Lampung province, Indonesia in 2004 was 266,586 ha, and the total cassava production was 4.67×10^9 kg (Lukita G., 2005). It means that there are abundant tapioca wastes, which sometimes evoke environmental problem by spreading offensive smell in the surroundings. The daily production of tapioca wastes is relatively high but their utilization for industries and livestock feed is limited. Therefore, the utilization of those wastes for environmental conservation must be developed, especially to improve soil properties as soil amendment.

The studies and investigations of industrial wastes amendment as alternatives for wastes disposal and environment enhancement have been widely conducted. The application of waste paper product by Brauer and Aiken (2006) for soil amendment near Booneville (USA) to decrease the risk of phosphorus (P) transport to surface water showed an increase of soil carbon content (i.e. organic matter) and the decreasing of soil bulk density, but had no effect on soil test P value. Seth *et al.* (2005) utilized 15 t ha^{-1} of composted sugar industry waste (pressmud) in a sodic soil to evaluate the soil properties and rice growth and found that the pressmud and its different composts significantly increased the plant height, grain and yield. Zheljazkov (2005) investigated that wool and hair wastes decompose slowly under both of field and greenhouse conditions, and their application of only 3.3 g kg^{-1} for soil amendment may support crop yield, which became double to five times bigger and would improve soil biological and chemical characteristics. Foley and Cooperband (2002) found that amending soil with paper mill residuals significantly increased total soil C and increased plant-available water by 5 to 45%. The experiment by Mantovi, P. *et al.* (2005) using composted sewage sludge for long-term application on soil resulted in the increasing of organic matter, total N and available P in the soil. Significant increases in total organic carbon and aggregate stability were observed in the plots amended with two-phase olive-mill waste on degraded agricultural soil (Lopez-Pineiro *et al.,* 2007).

The researches about the utilization of various organic materials mentioned above, including industrial wastes for soil amendment resulted in different effects. But, in spite of the abundance of tapioca production in South-East Asia, especially Indonesia, the application of tapioca wastes as an alternative for soil amendment and their effects on soil physical and biological properties are not covered in literatures. Therefore, the aim of this experiment was to investigate the influence of crop residue (rice husk) and tapioca wastes (cassava peel and cassava bagasse) in particular, on the amendment of soil physical and biological properties.

2. Materials and methods

The experimental field was located in a pineapple plantation owned by Great Giant Pineapple Company (GGPC) in Lampung province of Indonesia, lying on latitude 4°59′ S and longitude 105°13′ E. The site consisted of *Red-Yellow Podzolic* soil with predominantly sandy loam texture. The site used had previously been cultivated with pineapple for three continuous years followed by one-year cassava cultivation.

The investigation was conducted from July 2001 to September 2002. The experiment was laid out in a randomized complete block design with three replications. Each plot consisted of two beds, measuring 0.6 m × 15 m, and a height of 0.15–0.2 m. Each bed was planted with 60 smooth *cayenne* pineapple seedlings in two rows.

The experimental treatments were : control, rice husk mulch, cassava bagasse mulch, cassava peel mulch, cassava peel-soil mixture and black polyethylene film mulch. The typical size of rice husk used in the experiment was 8–10 mm in length, 2–3 mm in width and about 0.2 mm in thickness. Cassava bagasse was in granular form with the diameter of bigger than 0.84 mm. Cassava peel was chopped in irregular shape with 0.2–0.3 mm in thickness and 5–20 mm in diameter. The rice husk, cassava bagasse and cassava peel mulches were manually applied by hand at a rate of 30 kg m^{-2} based on wet basis, and this resulted in mulch height of 2–5 cm. The rate of 30 kg m^{-2} of application was adjustable to the abundant availability of organic amendments in the surounding. Regarding the cassava peel-soil mixture, cassava peel was thoroughly mixed with the soil to approximately 30 cm depth in the middle of June 2001. The seedlings were transplanted in late June 2001 and mulching was completely applied on soil surface in late July 2001. Pineapple fruits were harvested in September 2002. Total rainfall was 2,883 mm and total evaporation from evaporation pan class A was 1,782 mm during 15 months of experiment period. Maximum air temperature was 45.8℃ and this occurred on January 31st 2002, while the minimum air temperature of 17.1℃ was observed on August 15th 2002.

Initial soil sampling was performed to obtain the disturbed and undisturbed samples in late July 2001, just after mulching application accomplished. The final soil sampling was conducted in the early of October 2002, soon after the pineapples were harvested. Soil sampling was taken in the depths of 0–5 cm, 5–10 cm, 10–15 cm and 15–25 cm with three samples for each depth of each treatment. Undisturbed soil samples were performed with 100 cc soil cores to determine bulk density and soil water potentials, and disturbed soil samples were taken to determine particle size distribution especially clay fraction distribution, particle density, total soil organic matter (SOM) content and water-stable aggregate (WSA).

The soil water retention curve at −10, −30, −100, −300 and −1,500 kPa was determined using a centrifuge apparatus (Kokusan H-2000 B). Based on the standard methods of soil physical analysis described in JSSMFE (1991), particle density and particle size distribution were determined using pycnometer and the hydrometer methods, respectively. Clay fraction distribution with the particle size of $<$ 0.002 mm was classified according to the International Soil Science System (Foth, 1984). WSA was determined using a set of wet-sieving cylinder having 2 mm, 1 mm, 500 μm, 250 μm and 100 μm mesh sieves arranged in that order. The WSA was expressed as the percentage of soil mass with the aggregate fraction of $\geq$0.25 mm. The loss on ignition method was used to determine the SOM content (JSSMFE, 1991). The physical soil properties mentioned above were analyzed statistically using Mann-Whitney U-Test at 95% probability level.

Soil temperatures were measured using the silver-copper thermocouple cords at the depth of 0–25 cm, and soil moistures were measured at 0–30 cm of depth with the Time Domain Reflectometer (TDR) probes. Both of soil temperature and soil moisture measurements were connected to a CR23X data logger and recorded every ten minutes, the data were taken only at one point at each treatment.

Soil biological property observed was earthworm population at each rainy and dry season. Soil pits of 0.3 m × 0.3 m size were dug in each

Table 1 Changes of soil physical properties under various treatments

Treatment	Depth (cm)	Clay Fraction initial	Clay Fraction final	SOM initial	SOM final	Particle Density initial	Particle Density final	Bulk Density initial	Bulk Density final	WSA initial	WSA final
		$\times 10^{-2}$ kg kg^{-1}		$\times 10^{-3}$ kg kg^{-1}		$\times 10^{3}$ kg m^{-3}		$\times 10^{3}$ kg m^{-3}		kg kg^{-1}	
Control (No mulch)	0–5	20.0	8.4	34	28	2.670	2.687	1.14	1.10	0.28	0.33
	5–10	20.0	4.2	34	28	2.678	2.692	1.17	1.15	0.34	0.49
	10–15	20.0	5.0	35	29	2.689	2.688	1.17	1.24	0.30	0.47
	15–25	16.0	5.8	31	30	2.689	2.688	1.23	1.32	0.29	0.44
Significance within treat.		S		S		S		NS		S	
Rice husk mulch	0–5	6.2	4.0	33	36	2.687	2.671	1.06	1.04	0.35	0.36
	5–10	15.0	5.1	35	29	2.690	2.680	1.22	1.10	0.37	0.46
	10–15	10.8	9.0	34	33	2.684	2.676	1.32	1.04	0.38	0.43
	15–25	12.0	9.0	34	29	2.683	2.690	1.37	1.30	0.32	0.44
Significance within treat.		S		NS		NS		S		S	
Cassava peel mulch	0–5	20.0	4.9	33	31	2.662	2.673	1.15	1.01	0.47	0.54
	5–10	12.5	6.8	34	27	2.669	2.671	1.18	1.08	0.35	0.54
	10–15	24.0	13.1	35	27	2.669	2.679	1.23	1.28	0.33	0.54
	15–25	20.0	11.3	33	26	2.662	2.683	1.18	1.25	0.31	0.52
Significance within treat.		S		S		S		NS		S	
Cassava bagasse mulch	0–5	15.0	4.2	31	27	2.653	2.671	1.13	1.08	0.29	0.53
	5–10	12.0	6.0	32	28	2.652	2.680	1.19	1.07	0.30	0.49
	10–15	15.0	7.4	32	29	2.649	2.669	1.35	1.13	0.36	0.47
	15–25	18.0	7.4	31	28	2.652	2.664	1.37	1.23	0.35	0.43
Significance within treat.		S		S		S		S		S	
Black polyethylene film mulch	0–5	14.7	4.0	32	27	2.653	2.675	1.00	1.15	0.34	0.46
	5–10	10.1	4.0	32	27	2.677	2.710	1.16	1.14	0.27	0.40
	10–15	14.5	7.1	32	28	2.654	2.668	1.42	1.29	0.27	0.46
	15–25	7.6	6.4	32	27	2.680	2.674	1.32	1.30	0.14	0.52
Significance within treat.		S		S		NS		NS		S	
Cassava peel-soil mixture	0–5	19.0	10.0	55	31	2.512	2.664	1.03	0.71	0.30	0.58
	5–10	20.0	9.8	41	28	2.548	2.676	1.13	1.04	0.24	0.60
	10–15	20.0	6.3	36	29	2.439	2.669	1.30	1.29	0.25	0.58
	15–25	20.0	10.4	39	33	2.557	2.668	1.34	1.32	0.31	0.59
Significance within treat.		S		S		S		NS		S	

Note : Initial sampling : July 2001 ; Final sampling : October 2002
*S : Significant different at $P \leq 0.05$ using Mann-Whitney U-Test ; $n_1 = 12$; $n_2 = 12$

treatment and the earthworm population (individual m^{-2}) at depths of 0–15, 15–30 and 30–45 cm with three replications were sampled and observed using hand-sorting method (Svendsen, 1955). The earthworm population was then analyzed statistically using ANOVA followed by Duncan's Least Significant Difference (LSD) test at 95% probability level.

3. Results and discussion

3.1 Clay Fraction Distribution

The clay fraction changes at 0–5, 5–10, 10–15

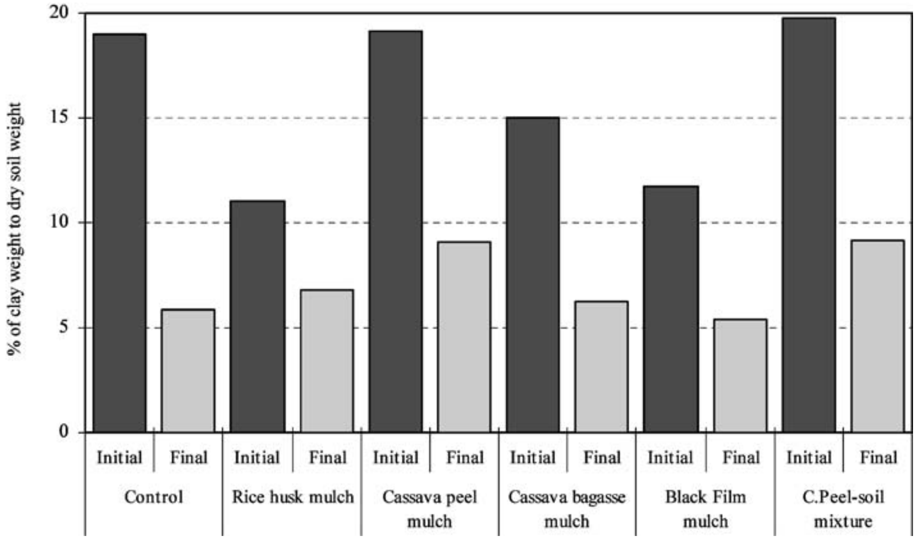

Fig. 1 Clay fraction change at 0-25 cm depth for 15 months (Initial sampling : July 2001 ; Final sampling : October 2002)

and 15–25 cm of depths in Table 1 shows that clay fractions decreased in all treatments at all depths. From Table 1, it is difficult to inform the decreasing trend of clay fraction at each depth between treatments since they do not show a particular tendency in detail. Therefore, Fig. 1 that shows the percentage of clay fraction at 0–25 cm depth at initial and 15 months later, is also presented to simply understand the changes. It is shown that the clay fractions significantly decreased in all treatments at 0–25 cm of soil depth. It was assumed that the clay was leached into deeper soil layers. Water infiltration through the soil surface during rainy days may have caused the fine particles dispersion, therefore clay fractions leached into deeper layers through cracks and soil pores. This clay leaching had caused texture change from sandy loam to loamy sand soil in the whole treatments. The degradation of soil physicochemical properties due to clay particle leaching has been an inherent big problem in and around the study site. Due to the fragile nature of the soil, deep plowing is usually undertaken before the next plantation cycle to bring the clay particles up to surface and thus improve soil physical properties. The practice of amending the soil with organic materials at the experiment site was also aimed at preventing clay-leaching problem. But, it has been shown distinctly that irrespective of the treatments applied, the clay content significantly decreased in all treatments. Vinyl mulch that completely protected soil surface from water infiltration during precipitation should have prevented clay from leaching into deeper layer. But the vinyl mulch, just as the organic mulches, in this study could not prevent the clay loss because water dripping through the open spaces of plant stands during rainfalls transported the fine particles from surface into deeper layer.

The rates of clay content decreases especially under rice husk mulch were smaller than cassava peel, yet the organic amendment materials investigated could not play any better role in preventing clay leaching in this study. Therefore, further study of other methods would be required to overcome the clay-leaching problem during pineapple cultivation in the experiment site.

3.2 Soil Organic Matter (SOM)

Organic materials are the main source of soil organic matter (SOM), hence one of the aims of organic amendment is to increase the SOM, which will improve soil physical, chemical and biological properties. But Table 1 shows that with the exception of rice husk mulching especially at 0–5 cm depth, SOM significantly decreased in all the soil layers under the various treatments. The rate of decomposition and the amount of organic materials are the keys to determining the availability of SOM in the soil.

Fifteen months after application, the cassava peel-soil mixture and cassava peel mulch treatments had not undergone decomposition and could be seen physically in its original form with the naked eyes. This indicates that 15 months was probably too short for cassava peel to decompose to contribute to the enhancement of SOM.

On the other hand, there was a speedy decomposition of cassava bagasse within a very short period after application. In that case, the decomposed SOM had already been mineralized into nutrients and used by the plants, hence SOM decreased at the end of the observation period.

In the meantime, 15 months after its application, the rice husks had been partially decomposed with the remnant still covering soil surface. Although insignificant, the partially decomposed rice husk may have slightly increased SOM at the upper layer (0–5 cm). It is expected that the remaining rice husks would continue to decompose beyond the 15 months study period to enhance SOM at the sub-layers.

According to the period and the rate of decomposition of each organic material and their role in SOM enhancement discussed above, rice husk can be recommended for use as organic amendment with a moderate decomposition rate.

3.3 Particle Density and Bulk Density

It is shown in Table 1 that particle density insignificantly decreased under rice husk mulching, while it significantly increased in the other treatments as well as the control, which experienced a negligible decrease at 10–25 cm depth. However, the slight increase in the SOM at surface layer (0-5 cm) under rice husk mulching had somehow improved the soil physical properties and consequently decreased the particle density. On the other hand, the increased particle density under control and the other treatments was accordingly due to the decrease of SOM.

It is also shown that bulk density significantly decreased in rice husk mulch and cassava bagasse mulch. However, despite insignificant, bulk density in other treatments also generally decreased. That is probably due to soil cracks that occurred during the dry season (low rainfall) when soil moisture was extremely low. Also, the decreased bulk density could be the result of earthworms burrowing activities. Beside the burrows formation, earthworm casts could also played a role in the significant general increase of water-stable aggregate (WSA), as shown in Table 1. Thus, the decrease of bulk density and the increase of WSA could be the results of earthworms burrowing activities.

3.4 Soil Gravitational Water and Available Water Content (AWC)

Table 2 shows that the total soil water contents from saturation (0 kPa) to field capacity (−10 kPa) at final stage were generally higher compared to the initial stage. The total soil water content from 0 to −10 kPa positively relates to the soil macro pores. Macro pores cause gravitational water to drain quickly and the total soil water content within 0 to −10 kPa is called the gravitational water.

Except under rice husk mulch, there were no significant differences in gravitational water increasing in all treatments. The general increase of gravitational water nevertheless show that soil macro pores also increased in all the treatments, which was probably due to the general decline of bulk density and the increase of WSA. Especially in the organic amendment treatments, the differences of macro pores at initial to final stage were bigger at all layers than the other treatments. Among all the organic amendments investigated, rice husk

Table 2 Changes of Soil Gravitational and Available Water Content

Treatment	Soil depth (cm)	Soil water content ($m^3 m^{-3}$)									
		① 0 kPa		② −10 kPa		③ −1500 kPa		①−② Gravitational Water		②−③ Available Water	
		Initial	final	Initial	final	Initial	final	Initial	final	Initial	final
Control	0− 5	0.57	0.59	0.34	0.32	0.25	0.23	0.23	0.27	0.09	0.09
	5−10	0.56	0.57	0.40	0.39	0.29	0.30	0.16	0.19	0.11	0.09
	10−15	0.56	0.54	0.39	0.40	0.28	0.31	0.18	0.14	0.11	0.09
	15−25	0.54	0.51	0.41	0.42	0.29	0.32	0.13	0.09	0.13	0.10
Significance within treat.								NS		S	
Rice husk mulch	0− 5	0.61	0.61	0.37	0.40	0.23	0.21	0.24	0.21	0.14	0.19
	5−10	0.54	0.59	0.44	0.36	0.26	0.26	0.11	0.24	0.18	0.09
	10−15	0.51	0.61	0.42	0.32	0.30	0.22	0.09	0.29	0.12	0.10
	15−25	0.49	0.52	0.46	0.43	0.34	0.32	0.03	0.09	0.12	0.10
Significance within treat.								S		NS	
Cassava peel mulch	0− 5	0.57	0.62	0.34	0.34	0.24	0.24	0.23	0.28	0.10	0.10
	5−10	0.56	0.60	0.36	0.32	0.26	0.24	0.20	0.28	0.10	0.08
	10−15	0.54	0.52	0.39	0.41	0.28	0.31	0.15	0.12	0.12	0.09
	15−25	0.56	0.53	0.38	0.37	0.26	0.27	0.18	0.16	0.12	0.10
Significance within treat.								NS		NS	
Cassava bagasse mulch	0− 5	0.57	0.60	0.34	0.32	0.26	0.23	0.23	0.27	0.09	0.09
	5−10	0.55	0.60	0.34	0.31	0.25	0.25	0.21	0.29	0.09	0.09
	10−15	0.49	0.58	0.44	0.35	0.33	0.25	0.05	0.23	0.11	0.09
	15−25	0.48	0.54	0.43	0.36	0.33	0.26	0.05	0.18	0.10	0.10
Significance within treat.								NS		NS	
Black polyethylene mulch	0− 5	0.62	0.57	0.31	0.36	0.21	0.26	0.31	0.21	0.10	0.10
	5−10	0.57	0.58	0.37	0.34	0.27	0.25	0.20	0.24	0.09	0.09
	10−15	0.46	0.52	0.43	0.42	0.33	0.33	0.03	0.10	0.10	0.09
	15−25	0.51	0.51	0.43	0.40	0.33	0.30	0.07	0.11	0.11	0.11
Significance within treat.								NS		NS	
Cassava peel-soil mixture	0− 5	0.59	0.61	0.31	0.29	0.22	0.18	0.28	0.32	0.10	0.11
	5−10	0.56	0.58	0.34	0.32	0.24	0.22	0.21	0.27	0.11	0.09
	10−15	0.47	0.55	0.32	0.42	0.28	0.31	0.15	0.13	0.04	0.11
	15−25	0.48	0.51	0.31	0.42	0.27	0.30	0.17	0.09	0.04	0.12
Significance within treat.								NS		S	

Note : Initial sampling : July 2001 ; Final sampling : October 2002
*S : Significantly different at $P \leq 0.05$ using Mann-Whitney U-Test ; $n_1 = 12$; $n_2 = 12$

mulch resulted in significantly more macro pores than cassava bagasse and cassava peel application treatments.

The available water contents (AWC) decreased or stable in general, except at the surface layer of rice husk mulching and in the deeper layer of cassava peel-soil mixture treatment. The increased AWC at surface layer of rice husk mulching is assumed due to the slight SOM increasing. It is generally shown that the in-

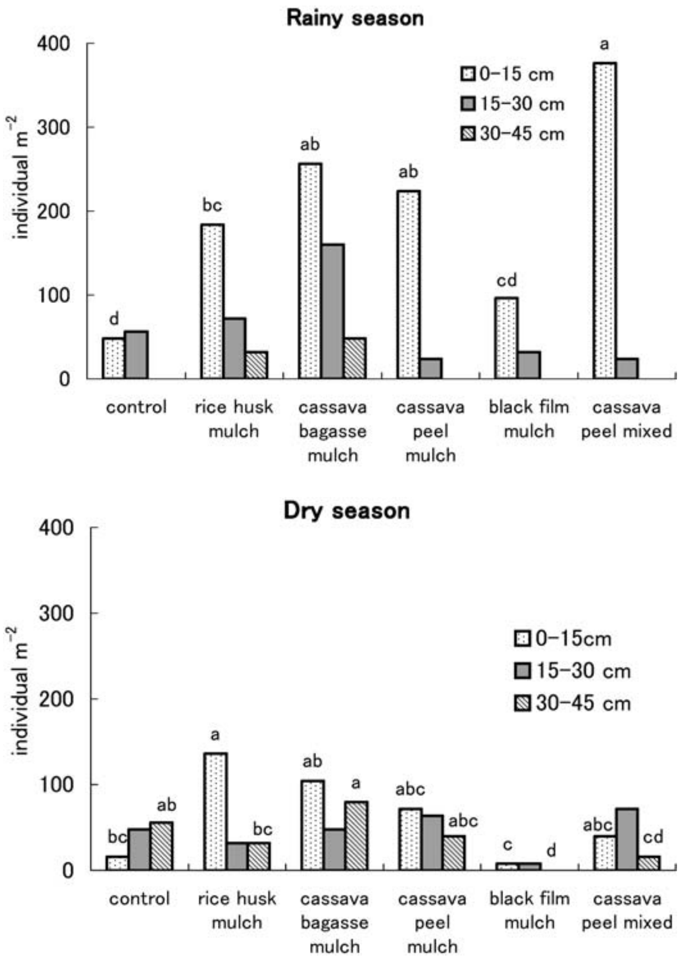

Fig. 2 Population of earthworms at each season
(n=9 ; rainy season sampling ; February 2002 ; dry season sampling : July, 2002 ; a,b,c,d : Means with different letters in the same depth for earthworm population are significantly different with Duncan's statistical test at $P \leq 0.05$)

vestigated organic amendments, especially for soil mulching insignificantly affected AWC. However, the current results show that amending cassava peel by mixing it into soil greatly enhanced the AWC especially at deeper layers.

3.5 Water-Stable Aggregate (WSA) and Earthworms Population

The percentage of soil mass with the aggregate fraction ≥0.25mm (water-stable aggregate/WSA) significantly increased in all the treatments including control and black polyethylene film mulch as shown in Table 1. Since WSA is also derived from earthworm casts, the significant general WSA increase in the present study somehow related to the earthworm activities (Fig. 2).

Figure 2 shows the earthworm populations in each treatment at three depths (0–15, 15–30, 30–45 cm) during the rainy season and dry season, respectively. Soil moisture and soil temperature (Table 3) are the soil properties that might be most affected by the seasons. But it is shown that those of the properties do not correlate well to that of the earthworm populations. However, earthworm populations were significantly higher in the organic

Table 3 Mean Soil Moisture and Soil Temperature During Each Season

Treatment	Soil moisture ($m^3 m^{-3}$)		Soil temperature (℃)	
	Rainy season	Dry season	Rainy season	Dry season
Control (No mulch)	0.349	0.313	26.2	26.3
Rice husk mulch	0.345	0.326	26.6	26.1
Cassava peel mulch	0.334	0.309	26.7	26.5
Cassava bagasse mulch	0.370	0.312	26.6	26.2
Black polyethylene mulch	0.337	0.302	27.3	26.9
Cassava peel-soil mixture	0.341	0.311	26.3	25.9

Note : Soil moisture was measured at 0–30 cm depth ; soil temperature was measured at 0–25 cm depth.
Rainy season is Feb. 2002 ; dry season is Jul. 2002

amendment treatments within 0–15 cm depth during rainy season. The earthworm populations were also rather higher in the organic amendment treatments during dry season although insignificant. The higher earthworm populations in both seasons in organic amendment treatments showed that organic amendments provided food source for earthworms. The abundance of earthworms in general positively affected soil physical properties.

4. Conclusions

Each investigated organic material for soil amendment resulted in different effects on soil properties 15 months after their application in the experimental field. Specifically, the moderate rate of rice husk's decomposition process slightly increased SOM of surface layer that may had led to somewhat decreased particle density and available water content enhancement. On the other hand, cassava bagasse mulch decomposed within very short period after application, and thus its roles especially in soil physical properties were no more noticeable in 15 months after its application. Due to the slow decomposition rate, 15 months was probably too short for cassava peel to contribute in SOM enhancement as well as other soil physical properties. However, the application of investigated organic materials for soil amendment resulted in the more abundance earthworm populations, bulk density decreasing, and the increases of macro pores and WSA in general.

Organic amendments provided food source for earthworms, and thus the earthworm populations were rather higher in those treatments. The existence and activities of earthworms in the soil certainly contributed positive effects in the soil properties, especially soil physical properties enhancement.

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籾殻とタピオカ残些を用いた土壌の物理的・生物的特性の改良

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要　　旨

インドネシア国ランポン州のパイナップル農園を対象にして，籾殻とタピオカ残渣（キャッサバの絞りかすとキャッサバの表皮）を土壌改良材として使用した時，土壌の物理性と生物的特性に与える効果を検証するために 15 ヶ月間の圃場実験を実施した。試験区は，対照区，籾殻で土壌面をマルチした試験区，キャッサバの絞りカスで土壌面をマルチした試験区，キャッサバの表皮で土壌面をマルチした試験区，キャッサバの表皮を土壌に混合した試験区，黒ビニールで土壌面をマルチした試験区からなる。実験開始時と実験終了後（実験開始から 15 ヶ月後）の土壌の物理性と生物的特性について調査し比較した。実験開始後 15 ヶ月目においても，籾殻マルチ試験区の表層土壌における有機物含有量が増加し，真比重が減少し有効水分量が増加するなど土壌の物理性を持続的に改善する結果が得られた。一方，キャッサバの絞りカスや表皮を利用した試験区では，実験開始から 15 ヶ月後，それらの分解が土壌の物理性を改善できなかった。しかしながら，これら有機物資材の施用は，雨季においてミミズの個体数を増加させ，その結果，土壌の乾燥密度を減少させ，大間隙や耐水性団粒を増加させた。乾季においては，土壌水分量が大きかった籾殻マルチ区のみミミズの個体数が増加した。

キーワード：インドネシア，土壌有機物，有機物マルチ，タピオカ残渣，ミミズ

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