

Effect of Coffee Pulp Compost and Terrace on Erosion, Run off and Nutrients Loss from Coffee Plantation in Lahat Regency, South Sumatra

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Received 4 December 2009 / accepted 17 March 2011

ABSTRACT

On some coffee plantations in Lahat Regency South Sumatra, in some places the farmers did not apply agricultural practices, such as tillage, conservation practices, and fertilizers. Many researches have been done to study about effects of organic fertilizer on soil nutrients content and plant growth as well as and the impacts of terrace on soil water content, run-off and erosion. However, there was less research in the highland area. Whereas the possibility of run off, erosion and nutrient leaching the high land area was high. Thus, it was important to apply terrace and organic coffee pulp in this farm. The aims of this research were to determine the effect of terrace and organic fertilizer on run off and soil erosion, nutrients loss and nutrient content in coffee leaves. Terrace system and organic fertilizer were applied on a one year old coffee plantation in Lahat Regency. Before the treatment applied, coffee pulp as organic fertilizer was decomposed in the chamber for about 2 months. The experiment was conducted in factorial in a Randomized Block Design with two factors. The first factor was coffee pulp compost (0, 3, and 6 Mg ha⁻¹), and the second factor was type of terrace (without, individual, and bund terraces). The size of each plot was 2 m width and 10 m length. Data was analysed by using LSD (Least Significant Different) test. The result shows that bund terrace reduced runoff and erosion significantly up to 79% (for run off water) and 78% (for eroded soil) compared to without terrace. Organic fertilizer did not affect run off and soil erosion. This may be caused by properties of coffee pulp compost which were fine particulates and the dosages of application were too low to cover soil surface. Bund terrace decreased significantly N, P, K nutrients in soil loss (sediment). The amount of N loss was reduced from 3.37 kg ha⁻¹ per four months (without terrace) to about 0.75 kg ha⁻¹ per four months (bund terrace). Terrace and organic fertilizer did not affect significantly nutrients content in the leaves, but P-content was low without organic fertilizer addition. It is suggested to apply bund terrace and higher organic fertilizer dose on the coffee farm, and further experiments when harvesting the yield (berries) are needed for the second year old coffee farm.

Keywords: Coffee, compost, erosion, nutrient, pulp, terrace

INTRODUCTION

In South Sumatra, coffee farms are located along the hill and mountain of Bukit Barisan. Moreover, coffee plantation occupies the upper part of rivers in South Sumatra, especially Musi River, which has 9 tributaries, which is called Batang Hari Sembilan. The management of coffee plantation will affect rivers in Musi river basin.

There was no soil tillage, no conservation practice and no fertilizer application on some coffee plantations in Lahat Regency of South Sumatra. The average yield of coffee bean was relatively low

(about 500 kg ha⁻¹) as reported by Hermanto (2006). It has been known that terrace can decrease run-off and erosion while it can increase water infiltration. Terrace has been used in many agricultural systems on sloping land. Therefore, soil and land degradation may be protected by terrace, and environmental deterioration may be hindered. Organic fertilizer which is made of decomposed organic material and terrace can increase nutrient content and plant growth, increase soil water content, and decrease run-off and erosion. Some farmers have quitted using anorganic fertilizers because of their negative impacts on soils and environment, then farmers have changed to organic fertilizer (bokashi) for sustainable agriculture (Dermiyati *et al.* 2009). The application of terrace and organic fertilizer on coffee plantation on sloping

land will produce healthy organic coffee for human being. Some farmers are used to apply coffee pulp as mulch, but they rarely apply terrace even on sloping land. However, coffee pulp has to be decomposed first, thus nutrients content will be readily available for plant. Rate of composting to reach C/N value of 14 for mixed Coffee pulp with rice husk, vetiver, and rubbish was 3 months (Winaryo *et al.* 1995) whereas for coffee pulp was only 4 weeks to reach C/N value of < 15 (Baon *et al.* 2005).

Organic matter could be used as mulch or as decomposed material on soil. Fungi were a more important factor in stabilizing soil macroaggregates, which were treated with fresh paper sludge. On the other hand, humic substances played a greater role in compost-amended soil (Bipfubusa *et al.* 2008). The use of mulch at dosage of 4 Mg ha⁻¹ increased water storage efficiency of 5-mm water application by 100% according to Ji and Unger (2001). It also could decrease water runoff and soil erosion. Compost was nutrients sources, however, application of organic compost without application of terrace was meaningless because it could loss quickly.

Some researches have shown that erosion was very high at coffee planted area without terrace application. Priatna (2001) reported that the erosion from land under different ages of coffee plants on 9-15% slopes ranged from 60 Mg ha⁻¹ yr⁻¹ on 1 year old plant, 37 Mg ha⁻¹ yr⁻¹ on 3 year old plant, 5 Mg ha⁻¹ yr⁻¹ on 6 year old plant. It seems that the older the plant the less the erosion, it might be caused by more coverage of plant canopy and plant litter.

Dariah *et al.* (2004) reported that erosion depended on soil physical properties, the erosion of soil with macropores > 24% and permeability > 6 cm hr⁻¹ was only 2 Mg ha⁻¹ per a three month. When soil macropores were < 4% and permeability was < 2 cm hr⁻¹, the erosion increased to 37 Mg ha⁻¹ per a three months. Similar results were also showed by Pujiyanto *et al.* (1996), where the erosion of Andisol was only 1.34 Mg ha⁻¹ yr⁻¹ on terrace without soil cover crop with 0.63 gcm⁻³ of soil bulk density. Sembiring *et al.* (1991) and Hardianto *et al.* (1992) monitored the application of terrace in Sumberkembar Village, Blitar from 1985 to 1991. The result shows that the erosion decreased from 17.10 Mg ha⁻¹ yr⁻¹ to 6.4 Mg ha⁻¹ yr⁻¹, beside that land productivity increased and run off decreased, thus the stability of watershed was maintained. It is evident that terrace is really beneficial in controlling soil erosion and run off on Andisol.

An organic fertilizer is more preferable than a

chemical fertilizer. Beside decreasing soil erosion, the farmers behavior which do not use chemical fertilizer, may lead to organic coffee farming system, which in turn safe for the environment and healthy for people. It was supported by the availability of coffee pulp in the farm, it was known that 1,000 beans and coffee pulp contain N (15.33%), P₂O₅ (2.27%), K₂O (3.67%); and parchment (endocarp) contain N (27.4%), P₂O₅ (0.3%), K₂O (1.87%) (Clifford and Wilson 1985). The application of 25 L⁻¹ tree⁻¹ yr⁻¹ of coffee pulp increased robusta yield of about 66% compared to control (Erwiyono *et al.* 2000).

Based on the above explanation, the aims of this research wre to determine the effect of terrace and organic fertilizer on run off and soil erosion, nutrients loss and nutrient content in coffee leaf.

MATERIALS AND METHODS

Study Site

This research was carried out in a coffee farm with 15% slope in Tanjung Tebat District, Lahat Regency and the research was done about four months. Terrace system and organic coffee pulp fertilizer were appllied on a year old coffee plantation. Coffee pulp was collected from the nearby mill and later decomposed for 2 months before application.

Research Method

The coffee pulp compost was prepared by placing collected coffee pulp in a chamber for incubation, covered with black plastic, watered and mixed weekly for two months.

While waiting for the decomposition process of the coffee pulp, the experimental plots were prepared by measuring each plot and bordered by metal fences for about 20 cm high and about 10 cm depth in the ground, the size of each plot was 2 m width and 10 m length. The first and second collectors were put on down slope of each plot for collecting run off water and sediment. The capacity of each collector was 37 liter. If there was water or sediment in the second collector, it was measured and multiplied by 7 because there were 7 small holes on the upper part of first collector.

Experimental Design and Analysis

The experimental design used was a Factorial in Randomized Block Design with two replicates. The first factor was dosages of coffee pulp compost which were 0, 3, and 6 Mg ha⁻¹. The second factor was types of terrace which were without

terrace, individual and bund terraces. The main and interaction effects were compared using LSD (Least Significant Different) at 5% level. Runoff water and sediment were measured from collectors for individual rainy days, then data were accumulated for one week. Data which were monitored and collected were run-off water, total eroded soil, nutrients (N, P, K and C) content in sediment and nutrients (N, P, K) content in coffee leaf. All samples were analysed in Soil Physical and Soil Chemical Laboratory, Faculty of Agriculture, Sriwijaya University. Soil particle-size analysis was based on Hydrometer Method, while Nitrogen, P and organic-C was analysed using Kjedal, Bray I, and Walkley and Black Methods, respectively.

RESULTS AND DISCUSSION

Rainfall, Run Off and Erosion

The amount of rainfall during this experiment from March to July 2009 varied from 0 to 113 mm week⁻¹ (Figure 1). This rainfall was high enough even though it was in dry season in June and July,

which was caused by orographic rainfall on mountain area.

The results show that the application of terrace decreased run off and erosion significantly compared to control (without terrace), but organic coffee pulp did not affect water runoff and erosion (Table 1). Bund terrace decreased run off from 12.75 mm (without terrace) to 2.63 mm. This means that bund terrace could collect and retain water longer than without terrace, then water infiltrated more on bund terrace compared to without terrace.

Bund terrace could also reduce the amount of run off thus more water could penetrate into the soil than control and individual terrace. This was caused by the function of terrace to level and shorten the slope, thus it was important to apply terrace on the land with 15% slope like in the coffee farm. These findings were similar to the research that carried out by Sembiring *et al.* (1991) and Hardianto *et al.* (1992) where terrace could decrease run off about 80%.

Coffee pulp compost did not affect the amount of run off significantly (Table 1). This may be caused by properties of coffee pulp (fine and loose), and also the amount of dosage (6 Mg ha⁻¹) was not enough to decrease run off. However, when it

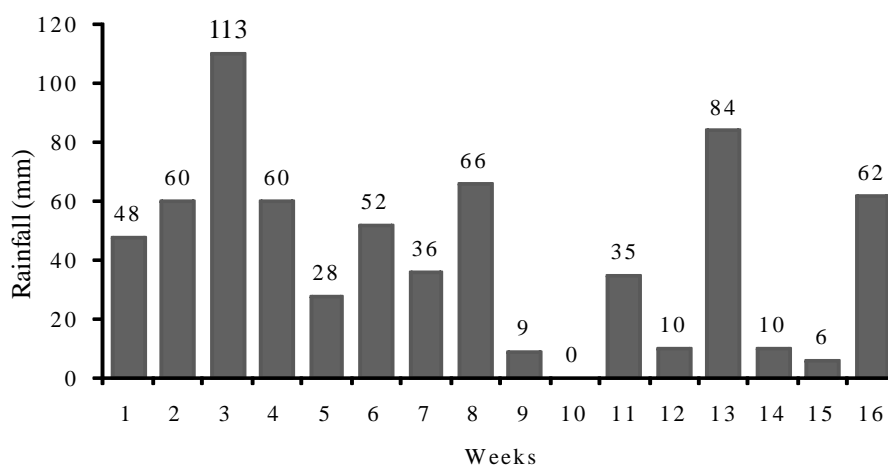


Figure 1. The amount of weekly rainfall in the time of experiment from March to July 2009.

Table 1. Effect of coffee pulp compost and terrace on the water run off.

Coffee Pulp Compost (Mg ha ⁻¹)	Total rainfall (666 mm in four months)			Main Effect of Coffee Pulp Compost
	Water run off (mm per four months)			
	NoTerrace	Individual Terrace	Bund Terrace	
0	14.121 a	12.720 b	3.752 c	10.197 a
3	10.729 b	11.400 ab	2.146 c	8.091 a
6	13.390 a	10.788 ab	2.007 c	8.728 a
Average of terrace	12.746A	11.636A	2.635B	

Note : The means followed by different small letters in the same column and capital letter in the same row indicate statistical significance at $p < 0.05$ level using the LSD test. Interaction and terrace LSD_{0.05} = 4.701.

Tabel 2. The interaction effect of terrace and coffee pulp compost on erosion.

Dosage of Coffee Pulp Compost (Mg ha ⁻¹)	Erosion (Mg ha ⁻¹ per four months)		
	Without Terrace	Individual Terrace	Bund Terrace
0	1.03 b	0.99 b	0.30 a
3	1.33 b	1.39 b	0.25 a
6	1.11 b	1.09 b	0.20 a

Note : The means followed by different letters in the same column indicate statistical significance at $p < 0.05$ level using the LSD test. Interaction $LSD_{0.05} = 0.43$.

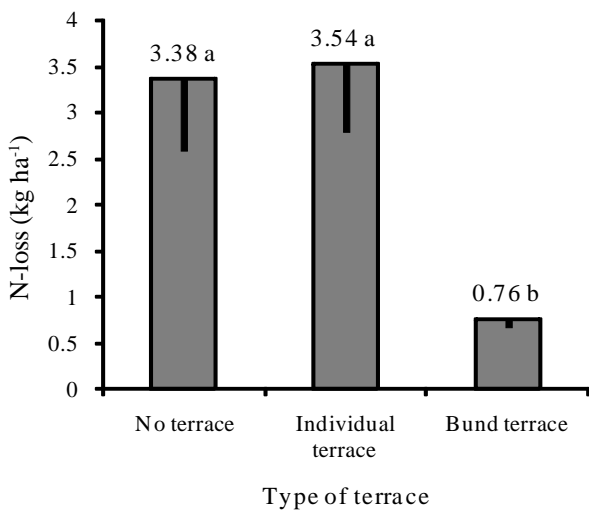


Figure 2. The effect of terrace on N loss in eroded soil. Value followed by similar letters are not significantly decreased N loss (small bar was standard deviation).

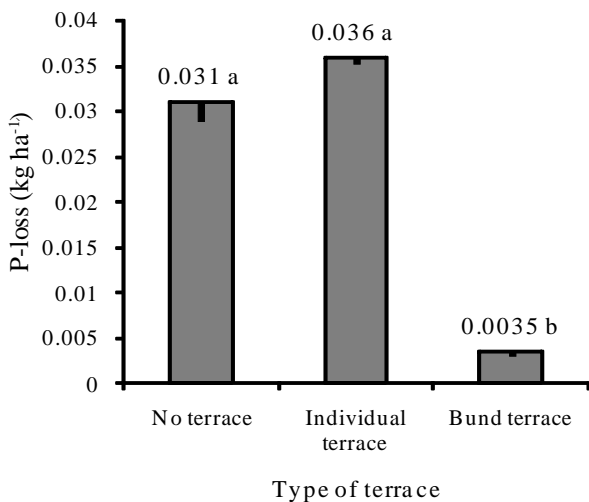


Figure 3. The effect of terrace on P loss in eroded soil, value followed by similar letter are not significantly decreased P loss (small bar was standard deviation).

combined with terrace, the application of 0 Mg ha⁻¹ coffee pulp compost and bench terrace decreased about 68% run off water. This means terrace is more significant than organic fertilizer in reducing run off. But, the amount of run off water was relatively low on Andisol soil, this was caused by crumb, granular and well developed soil structure. The same result was also shown by Khasanah *et al.* (2004) that the amount of run off from one year old coffee farm on Andisol was only from 0 to 10 mm.

Bund terrace decreased erosion significantly compared with other treatments. Bench terrace decreased erosion by 78% from 1.15 Mg ha⁻¹ (without terrace) to only 0.25 Mg ha⁻¹ (with bund terrace) during 4 months (Table 2). This may be caused by soil raised of bund terrace was bigger than those of individual terrace, thus it was more effective in decreasing erosion. These findings are similar to other Andisol soils elsewhere. Sembiring *et al.* (1991); Hardianto *et al.* (1992); Pujiyanto *et al.* (1996) found that the erosion was mostly less than 3 Mg ha⁻¹ yr⁻¹ when terraces were applied. Dariah *et al.* (2004) stated that low erosion on Andisol soil may be caused by both high soil macropores and permeability, which was typical of Andisol soil. Similar results also reported by Rachman *et al.* (2004) that soil macropores was correlated to soil permeability.

Therefore it is important to apply terrace on Andisol eventhough the research was done only about 4 months and in nearly dry season. Because, if the amount of erosion was added from the whole first year, second year and third year, thus the total erosion would be high.

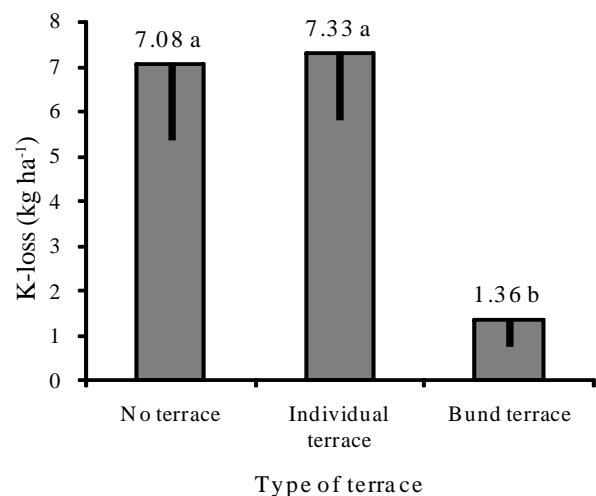


Figure 4. The effect of terrace on K loss in eroded soil, value followed by similar letter are not significantly decreased K loss (small bar was standard deviation).

Amount of Nutrient Loss in Sediment

The result shows that main effect of bund terrace and interaction between terrace and organic fertilizer decreased the amount of nutrients loss significantly (Figure 2, 3, 4 and Table 3). Bund terrace gave the lowest N loss (0.76 kg ha⁻¹ per four months) compared with individual terrace 3.54 kg⁻¹ ha⁻¹ per four months and without terrace (3.38 kg⁻¹ ha⁻¹ per four months). This indicates that bund terrace decreased erosion and consequently decreased N in sediment. Thus bund terrace was needed in this coffee farm, because loss of N gradually from this land could hinder plant growth. The best combination between terrace and organic fertilizer were between bund terrace and 0 Mg ha⁻¹ coffee pulp compost, where N lost was about 1.90 kg⁻¹ ha⁻¹ per four months. Thus terrace was really important in decreasing N lost from coffee farm for along time effect.

Eventhough terrace affected P nutrient loss significantly, the loss of P in eroded soil was very low, these caused by P content in soil was lower

than other nutrients. The results show that the best combination was between bund terrace and 6 Mg ha⁻¹ of coffee pulp compost where P nutrient lost was 0.0021 kg, on the other hand without terrace was 0.0086 kg.

Potassium loss was also significantly decreased by bund terrace, where the amount of eroded K was 7.08 kg⁻¹ ha⁻¹ per four months without terrace and to 2.77 kg⁻¹ ha⁻¹ per four months with bund terrace. Combination of bund terrace and 6 Mg ha⁻¹ of organic fertilizer decreased K loss from 4.96 kg⁻¹ ha⁻¹ per four months to 2.09 kg⁻¹ ha⁻¹ per four months (without terrace). Thus the application of composted coffee pulp compost and terrace are suggested to be applied on coffee farm at sloping land (15%) in order to decrease the amount of nutrients loss.

Nitrogen, Phosphorus and Potassium Contents in Coffee Leaves

The results show that the application of terrace and coffee pulp compost did not affect nutrients content in the leaf. The nutrients content varied

Table 3. The effect of terrace and coffee pulp compost on nutrients loss.

Treatments		Nutrients Loss in Sediment (kg ⁻¹ ha ⁻¹ per four months)		
Terrace	Compost (Mg ha ⁻¹)	N	P	K
Without	0	2.80 b	0.0080 a	4.96 abc
Without	3	4.20 a	0.0131 a	7.21 bcd
Without	6	3.10 b	0.0103 a	9.08 d
Individual	0	2.95 b	0.0104 a	5.48 abcd
Individual	3	4.30 a	0.0132 a	8.74 cd
Individual	6	3.35 ab	0.0120 a	7.78 cd
Bund	0	0.90 c	0.0027 b	3.30 ab
Bund	3	0.75 c	0.0021 b	2.92 ab
Bund	6	0.60 c	0.0017 b	2.09 a
Interaction		LSD (0.05) = 1.05.	LSD (0.05) = 0.0063	LSD (0.05) = 5.12

Note: The means followed by different letters in the same coloumn indicate statistical significance at *p* < 0.05 level using the LSD test.

Table 4. The effect of terrace on nutrients content in coffee leaves.

Type of Terrace	Nutrient Content in Leaves (%)		
	N	P	K
Without terrace	3.67(high)	0.08 (low)	1.67(medium)
Individual terrace	3.95 (high)	0.18 (high)	2.02 (high)
Bund terrace	3.79 (high)	0.12 (medium)	1.73 (medium)
Average	3.80 (high)	0.13 (medium)	1.81 (medium)

Note: Status were based on (FAO 2011).

Table 5. The effect of coffee pulp compost on nutrients content in coffee leaves.

Coffee Pulp Compost (Mg ha ⁻¹)	Nutrient Content in Leaves (%)		
	N	P	K
0	3.75 (high)	0.07 (low)	1.44 (medium)
3	3.83 (high)	0.16 (high)	1.79 (medium)
6	3.83 (high)	0.15 (high)	2.19 (high)
Average	3.80 (high)	0.12 (medium)	1.80 (medium)

Note: Status were based on (FAO 2011).

from low to high (FAO 2009) standard where all N content were high, P were from low to high and K were from medium to high. It seems that nutrient content in the coffee leaves can be satisfied from nutrient contents in soil, except for phosphorus without the addition of coffee pulp compost.

Medium to high content of N and K in the leaves might be caused by high rainfall on the mountain area and high soil N and K content (analytical data), beside that the coffee farm was a year old and has not produced berry yet. So the addition of organic fertilizer was important to fulfill P adsorption, however it needed further investigation for the second year old plant.

However, P content in the leaves was low without coffee pulp compost (Table 5), this was caused by coffee pulp compost contained high P as reported by Clifford and Willson (1985) that coffee pulp contained N (27.4%), P₂O₅ (0.3%), K₂O (1.87%). This suggests that coffee pulp compost as organic fertilizer and as P source is needed by coffee plant.

Bund terrace and organic fertilizer are needed to be applied in coffee plantation because these inputs can decrease the amount of run off water and eroded soil, subsequently decrease N and K loss and increase P content in the leaves in turn it will affect plant growth and yield in the second year of plant. Otherwise, soil fertility will deteriorate gradually without applying terrace and organic fertilizer.

CONCLUSIONS

The application of bund terrace decreased runoff and erosion significantly up to 79% (for run off water) and 78% (for eroded soil) compared to without terrace. Organic fertilizer did not affect run off and soil erosion. Bund terrace decreased significantly N, P, K nutrients loss from soil. The amount of N was reduced from 3.37 kg⁻¹ ha⁻¹ per four months (without terrace) to only about 0.75

kg⁻¹ ha⁻¹ per four months (bund terrace). Due to the high nutrients content, especially N and K in soil the more was soil eroded the more the nutrient was lost. Terrace and organic fertilizer did not affect nutrients content in the leaves, however P-content in without organic fertilizer addition was low.

It is suggested to apply bund terrace and coffee pulp compost on coffee farm, and further experiments are needed for the second year old coffee farm.

ACKNOWLEDGEMENTS

The author thanks to John Bako Baon, Andy Wijaya, Adipati Napoleon, Siti Nurul Aidil Fitri, Estiko, Ade Surakhman, and Suparto for their help and contributions in conduction this experiment. Funding for this study was supported by KKP₃T, Ministry of Agriculture, Republic of Indonesia.

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