Research article

Effects of Retting Treatment on Coconut Husk Buffer Strips for Eliminating Nutrient Losses

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Abstract Coconut husk has been applied as buffer strips for soil erosion control on slope upland fields in Bohol of the Philippines. However, attention has been paid to the losses of nitrogen and phosphorus components not only those leached from synthetic fertilizer applied in upland fields but also those components released from coconut husk buffer strips. Thus, pretreatment of coconut husk by retting before its installation into the field has been proposed. The objective of this study is to find out the effect of ret treating the coconut husk utilized as buffer strips on eliminating its releasing nitrogen and phosphorus components. Coconut husks were trimmed then minor pounding by hammer were applied to meet the desired porosity of the material as buffer. Retting treatment of 41.34 g in dry mass of coconut husk was carried out by soaking into 1,300 ml of distilled water for 10 days to extract its nitrogen and phosphorus components. Ret treated coconut husk were installed into stainless slope model plot filled with Philippine soil and set at 8 degrees in slope. Another plot was also prepared and installed with untreated coconut husk then rainfall simulation was carried out into both plots. The experimental results showed that the amount of nitrogen released from the plot installed with ret treated coconut husk buffer strip was significantly lower than that of untreated husk buffer strip at 99% significant level. Therefore, it was concluded that 10 days retting treatment of coconut husk for buffer strips was effective on eliminating the release of nutrient particularly on nitrogen from leaching.

Keywords coconut husk, retting, nitrogen, phosphorus, bio-fertilizer

INTRODUCTION

Upland fields with protruding stones and rocks on ground surfaces as well as abandoned farmland are dominant particularly in the southwestern part of Bohol, Philipines (Torillo and Mihara, 2011). Moreover, these lands are mostly located on sloped-areas with 8-18% and even some portions with more than 18% slope, particularly for subsistence agriculture (OIDCI, 2006). Together with high squalls, uplands in the island are susceptible to soil erosion causing rapid degradation of land.

Meanwhile, about 5 million coconut trees are cultivated in the island of Bohol (OIDCI, 2006) producing large amount of coconut husk. These coconut husks were considered as waste residue and left rotten in the site. In this study, utilizing coconut husk, a locally available material has been focused from a view point of conservation agriculture in Bohol. However, coconut husk that were installed as buffer strips for soil erosion control tended to release nitrogen and phosphorus. This tendency was observed during the slope modeling under artificial rainfall simulator (Torillo and Mihara, 2011). Those nutrients released from the coconut husk may leach through percolation and surface runoff resulting water pollution into downstream. Therefore, treating of coconut husk before its installation as buffer strips through retting has been recommended.

The objective in this study is to find out the effect of retting treatment of coconut husk for buffer strips on eliminating its nitrogen and phosphorus release.

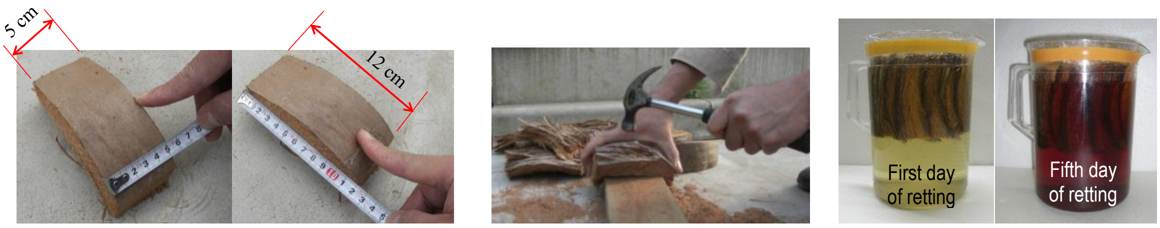
MEHODOLOGY

Retting treatment of coconut husks

Nutrient component particularly on phosphorus can be extracted from the coconut husk by retting method (Torillo and Mihara, 2012). Thus, retting treatment of coconut husks has been applied by soaking into distilled water.

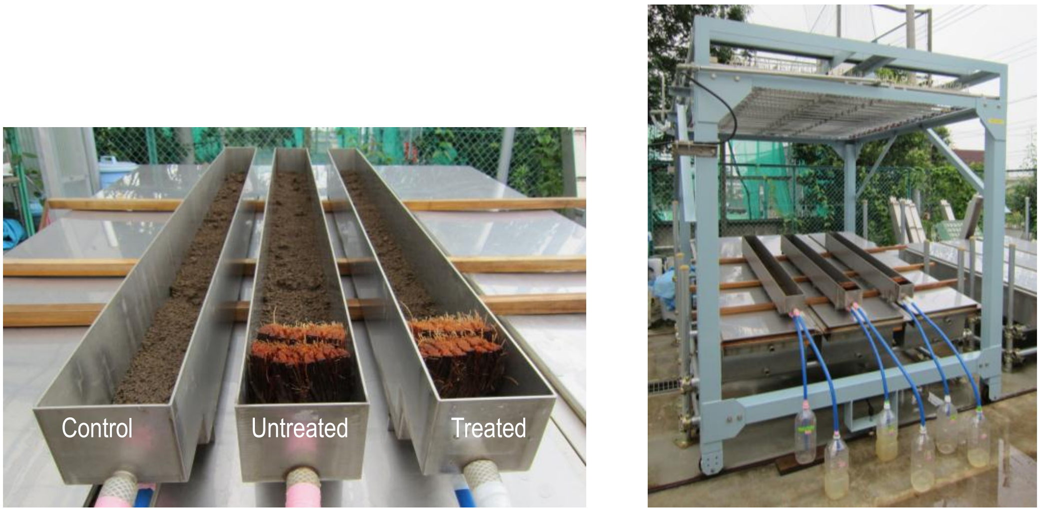
Coconut husks were cut and trimmed into 5 cm wide and 12 cm length then minor pounding by hammer was done to make into a porous material similar to that being installed into the site as buffer strips. Four pieces of pounded coconut husks were prepared while two of them were intended for retting treatment and the other two pieces were retained as untreated coconut husks. Small amount of coconut husk`s sample was taken for analyzing total nitrogen (T-N) and total phosphorus (T-P) component after the decomposition with sodium hydroxide (NaOH) and potassium peroxodisulfate ($K_2S_2O_8$). Concentrations of T-N and T-P were measured by spectro-metric methods (Mihara and Ueno, 2000).

Pounded two pieces of coconut husks weighing 41.34 g in dry mass for retting treatment were then soaked into 1,300 ml of distilled water. Retting treatment was carried out up to ten days as Torillo and Mihara (2012) reported that the optimum period of releasing nutrient components from coconut husk was at the tenth day of retting. After ten days passed of soaking, coconut husks were taken out and ret liquor was sampled for analyzing the released amount of T-N and T-P from the coconut husk.



a) b) c)

Fig. 1 Procedures in preparing the coconut husks for retting treatment such as a) cutting, b) pounding and c) retting



a) b)

Fig. 2 Slope model plots in a) controlled, untreated husk buffered and treated husk buffered plots and b) slope model plots under artificial rainfall simulator

Slope modeling with coconut husks buffer strip

It was proven that there was no significant difference between the two rows of coconut husk buffer strip and the two rows coconut husks buffer strip with 25 cm husk mulch on mitigating soil losses (Torillo and Mihara, 2011). Therefore, in this study two rows of coconut husk buffer strips have been installed into slope model plots.

Three stainless slope model plots were prepared as controlled plot, treated coconut husk buffered plot and untreated coconut husk buffered plot. Each slope model plot (130 cm long and 11 cm wide) were filled up with Philippine soil having clay percentage at 63.8%, silt at 8.1% and sand at 28.1% (Torillo and Mihara, 2011) of around 7.5 kilograms. Ret treated and untreated coconut husks were installed at the lower toe of the plots as treated coconut husk buffered plot and untreated coconut husk buffered plot, respectively. Those two slope model plots along with controlled plot were set at degrees in slope. Rainfall simulation was carried out at rainfall intensity of 60 mm/h within two hours. Suspended water samples from surface discharge were collected every 15 minutes for the first hour then every 30 minutes for the second hour. Percolation water was collected at each plot after 24 hours from the end of rainfall simulation. Surface water discharge and percolated water samples were analyzed for total nitrogen (T-N) and total phosphorus (T-P). Surface water discharge samples were also measured for soil losses by oven drying method. Three repetitions of rainfall simulation were carried out in separate days.

RESULTS AND DISCUSSION

Total nitrogen and total phosphorus released from coconut husk during retting treatment

Minor pounded coconut husks of 41.34 g in dry mass were soaked into 1,300 ml of distilled water within ten days. In the tenth day of soaking, distilled water soaked with coconut husks or called ret liquor (Fig. 1-c) were sampled then analyzed for total nitrogen (T-N) and total phosphorus (T-P). The amounts of T-N and T-P in coconut husk before soaking into the distilled water were also analyzed to determine the released amounts of these nutrients from coconut husk by retting.

Analysis data showed that the amounts of T-N and T-P in raw coconut husk were 0.792 mgN/g and 0.863 mgP/g, respectively (Table 1). During the tenth day of soaking or retting, the amount of T-N in ret liquor was 0.119 mgN/g and 0.729 mgP/g of T-P. Those values indicated that 15.02% of T-N component and 84.47% of T-P component from coconut husks were released into ret liquor within ten days of retting. The tendency of high released of T-P from coconut husk was supported by Havis and Alberts (1993) which nutrient leaching dynamics from partially decomposed corn residue was examined in a laboratory simulation experiment. They found out that more PO_4-P leached than NO_3-N and NH_4-N.

Table 1 Amounts of T-N and T-P in coconut husks and in ret liquor

	Amounts of nutrients in coconut husk	Amounts of nutrients released into ret liquor	Percentage of nutrient released from coconut husk
Total nitrogen (T-N)	0.792 ± 0.045 mgN/g	0.119 ± 0.028 mgN/g	15.02%
Total phosphorus (T-P)	0.863 ± 0.011 mgP/g	0.729 ± 0.188 mgP/g	84.47%

Effects of coconut husk buffer strips on mitigating soil losses

Two pieces of coconut husks at 41.34 g in dry mass were ret treated while other two pieces were retained as untreated coconut husk. To observe the effects of retting treatment on eliminating total nitrogen (T-N) and total phosphorus (T-P) in coconut husks for buffer strips, those pieces of coconut husk were installed into slope model plots then simulated under artificial rainfall.

Mihara (2001) reported that nitrogen and phosphorus components were transported by sediment and suspended solids which was observed in USLE plots under natural rainfall. In this connection, the amount of soil losses was also observed in this study. As shown in Fig. 3 that the trend of cumulative amount of soil losses is increasing with the repetition of rainfall simulation among slope plots. This tendency is due to the accumulation of transported soil with the repetition of rainfall at the lower toe of the plots. Hence, the depth of the sediment deposited at buffer strip increases with time and substantially altering the geometry and gradient of the surface (Rose et al., 2003). This trend results smaller soil particles to be runoff and passes through voids in buffer strips.

The results showed that the amount of soil losses at treated and untreated coconut husk buffered plots were lower at an average of 29, 35 and 42% than that of controlled plot during the first, second and third rainfall simulation, respectively (Fig. 3). It was clearly indicated that coconut husk buffer strips mitigated soil losses which significant differences at $p<0.01$ were observed.

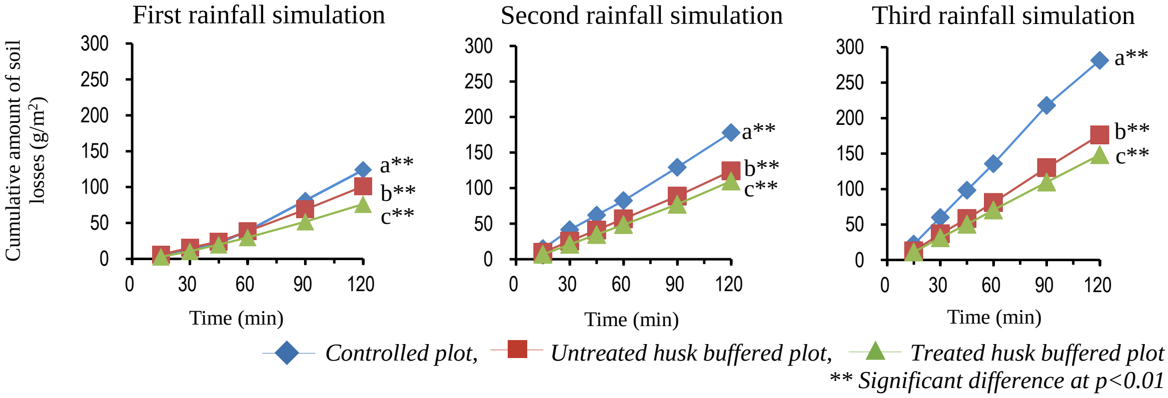


Fig. 3 Cumulative amount of soil losses with time during the first, second and third rainfall simulation

Effects of retting treatment on eliminating total nitrogen and total phosphorus in coconut husk utilized as buffer strips

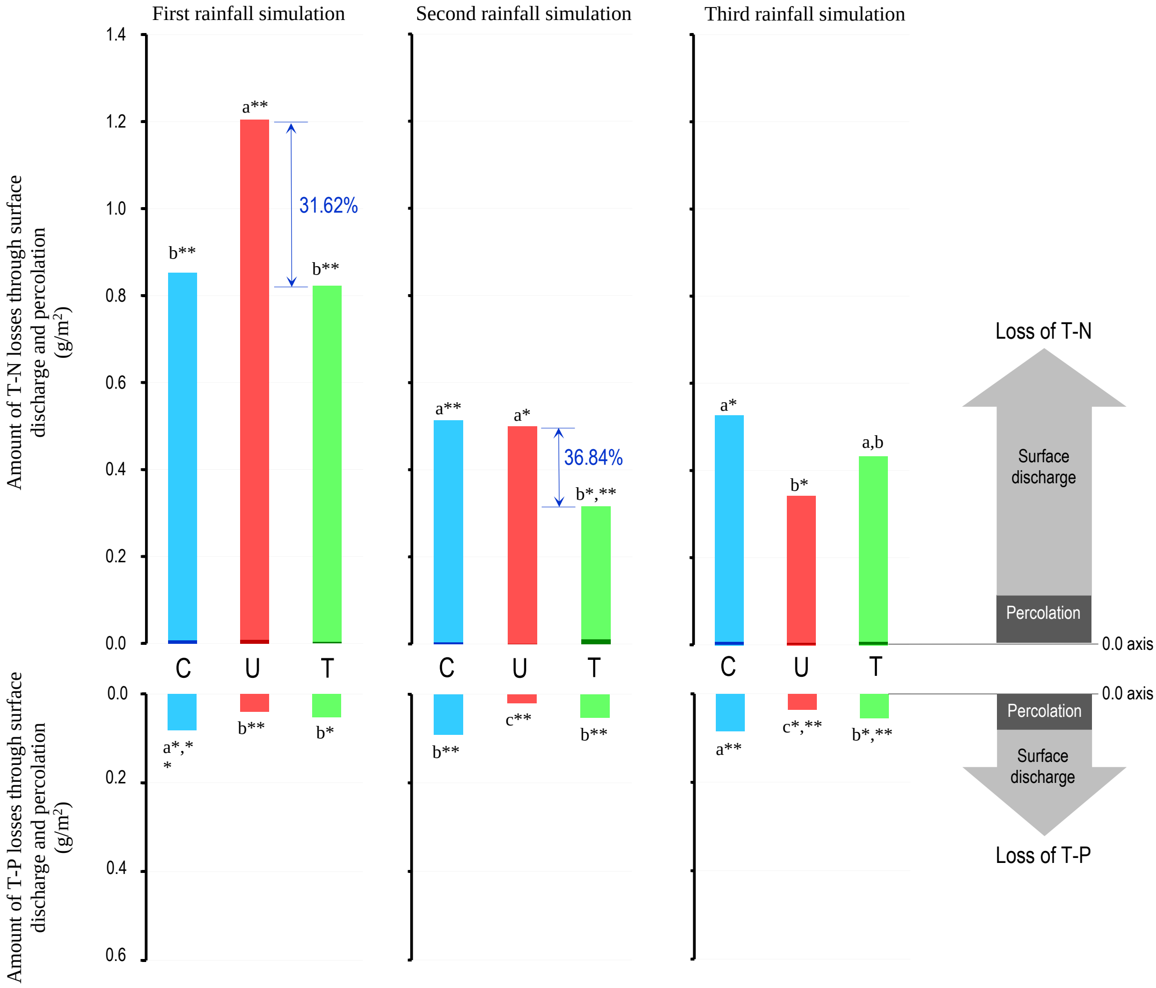
Fig. 4 shows the amounts of T-N and T-P losses through surface discharge and percolation. It is indicated in the diagram at the right side of the figure showing the values plotted in histogram from zero x-axis and up is the amount of T-N losses. Meanwhile, values plotted in histogram from zero x-axis and down is the amount of T-P losses. Darker colors in histogram are the amounts of T-N and T-P losses through percolation and lighter colors are the amount of T-N and T-P losses through surface discharge.

The amount of T-N losses through percolation and surface discharge are shown both (Fig. 4) to observe the balance losses of this nutrient. However, the amount of T-N losses through percolation was averagely 95 times lower than that of T-N losses through surface discharge. For instance in the case of (T) treated coconut husk buffered plot during the first rainfall simulation, T-N losses through percolation was 0.004 g/m^2 compared to 0.817 g/m^2 of T-N losses through surface discharge. Thus, T-N losses through percolation were insignificant that it did not affect in the statistical quantification of T-N losses.

During the first rainfall simulation, the (U) untreated coconut husk buffered plot showed higher amount at 0.378 g/m^2 accounting 31.62% of T-N losses higher than that of (T) treated coconut husk with a significant difference at $p<0.01$. This trend indicated that T-N component in coconut husk has been eliminated by retting treatment. However, (T) treated coconut husk buffered plot showed no significant difference than that of (C) controlled plot. This signifies that treated coconut husk buffer showed less effective on mitigating T-N losses from the plot.

A sudden decrease of T-N losses among three plots was observed from first rainfall simulation to second rainfall simulation test. This might be due to most of T-N component in soil that are susceptible for runoff had been transported during the initial rainfall simulation. During the second rainfall simulation, (U) untreated coconut husk buffered plot also showed higher amount at 0.161 g/m^2 accounting 36.84% of T-N losses higher than that of (T) treated coconut husk buffered plot. Although, only $p<0.05$ of significant difference was observed. It was also showed that treated coconut husk buffer were able to mitigate T-N losses since (T) treated coconut husk buffered plot has 0.173 g/m^2 of T-N lower than that of (C) controlled plot with significant difference at p<0.01.

During the third rainfall simulation, although (T) treated coconut husk buffered plot appeared to be higher losses of T-N than that of (U) untreated coconut husk buffered plot, it was indicated that there was no significant difference between the two plots. Therefore, based on the experimental results, retting treatment of coconut husk influences in eliminating T-N losses.



C:*Controlled plot* **U**:*Untreated coconut husk buffered plot* **T**:*Treated coconut husk buffered plot*
** Significant difference at p<0.05, ** Significant difference at p<0.01*

Fig. 4 Amounts of total nitrogen (T-N) and total phosphorus (T-P) losses through surface discharge and percolation

The amount of T-P losses are also shown in Fig. 4 which is below the zero x-axes. It was also observed that the amount of T-P losses through percolation is significantly lower than that of T-P losses through surface discharge. For instance, the amount of T-P losses through percolation from (T) treated coconut husk buffered plot was 1×10^{-4} g/m^2 accounting 450 times lower than that of its surface discharge which is 0.045 g/m^2. Thus, the amount of T-P losses through percolation is also very insignificant to affect the statistical quantification of T-P losses.

The trend of T-P losses from all of the plots showed almost no changes from first to third rainfall simulation test. Although coconut husk buffered plots (U and T) had lower amounts of T-P losses than that of (C) controlled plot, T-P losses from (T) treated coconut husk buffered plot tended to be higher than that of (U) untreated coconut husk buffered plot where in significant differences at p<0.01 and p<0.05 were observed during the second and third rainfall simulation tests, respectively. This tendency might be due to the longer contact time of coconut husk with distilled water during retting treatment. As Cermark et al. (2004) reported that more amount of PO_4-P was leached from corn residue with longer time of immersing into the solution of distilled water and inorganic salt. Thus, leaching of T-P from coconut husk residue has similar trend to that of corn residue which releases more amount of phosphorus component. The experimental results signified that with and without ret treating of coconut husk have less influence on eliminating T-P losses.

On the other hand, even though retting treatment of coconut husk tended to be less effective on eliminating T-P losses, it was observed that quantitatively the amount of T-P losses were very much lower than that of T-N losses. As shown in Fig. 4 that the amount of T-P losses from (T) treated coconut husk buffered plot were 18, 6, and 8 times lower than that of T-N losses during the first, second and third rainfall simulation tests, respectively. In addition, the amount of T-P at 0.863 mgP/g (Table 1) being released into the distilled water during the retting treatment is significantly larger than that of T-P which loss from treated coconut husk buffered plot at an average amount of 0.046 g/m^2.

CONCLUSION

This study dealt with the effect of retting treatment of coconut husk for buffer strips on eliminating its nitrogen and phosphorus components. It was indicated that around 15% of total nitrogen (T-N) and 85% of total phosphorus (T-P) component from coconut husk were released into distilled water within 10-day period of retting treatment. It was also proven that retting treatment was able to eliminate T-N losses at 31.62% and 36.84% during the first and second rainfall simulation tests, respectively. Thus, this amounts of T-N that were eliminated is important to taken into consideration as a benefit of retting treatment. In addition, although retting treatment tended to be less effective in eliminating T-P losses during the slope modeling test, the amount of T-P that was released into the distilled water during the retting was very high than that of T-P being loss from treated coconut husk buffer. The amount of T-P released into the distilled can be efficiently utilized for liquid bio-fertilizer. Therefore, retting treatment of coconut husk not only eliminates T-N losses but also it is an effective method to extract T-P component in the coconut husk.

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