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Effect of tillage practices on soil and nutrient loss from slopping land of hills in Bangladesh

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Abstract

Field experiments were conducted to examine the effect of tillage soil and nutrient loss from slopping land of hills in Bangladesh. A study was carried out during March 2016 to February 2017 in Bandarban of Chittagong hill tracts to assess the productivity, soil and nutrient loss as well as the nutrient balance in Jhum cultivation system and develop improved management practices to minimize the soil and nutrient loss in the area. First a survey was done to know the current soil fertility status in a hilly area and current livelihood of tribal people in Bandarban. There were four treatments for the experiment: T1No-tillage + No crop, T2 Well tilled + No crop, T3 Well tilled +Jhum crops and T4 Minimum tilled + Jhum crop. The experiments were laid out in randomized complete block design (RCBD) with three replications. Survey result shows that Jhum cultivation causes soil erosion and does not fulfill food shortage of hilly people. Hill soils of different slopes were acidic in nature. Changes in soil properties were prominent on the surface soil depth (0-15cm) than at the deeper soil depth. The maximum soil loss was recorded from well-tilled and no crop plots and the minimum soil loss recorded in no-tilled without crop. The present study reveals that the highest soil loss occurred for the maximum length of 30m plot along the slope, while it was the minimum for the minimum length of 5m plot.

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Introduction

Tillage is the agricultural preparation of soil by mechanical agitation of various types, such as digging, stirring, and overturning. Examples of human-powered tilling methods using hand tools include shoveling, picking, mattock work, hoeing, and raking (Kaur, R.; Arora, V., 2019). Examples of draft-animal-powered or mechanized work include ploughing (overturning with moldboards or chiseling with chisel shanks), rototilling, rolling with cultipackers or other rollers, harrowing, and cultivating with cultivator shanks (teeth). "Tillage" can also mean the land that is tilled (Sastre, B. *et al.*, 2017). The word "cultivation" has several senses that overlap substantially with those of "tillage". In a general context, both can refer to agriculture. Within agriculture, both can refer to any kind of soil agitation. Additionally, "cultivation" or "cultivating" may refer to an even narrower sense of shallow, selective secondary tillage of row crop fields that kills weeds while sparing the crop plants.

Soil erosion is the displacement of the upper layer of soil, it is one form of soil degradation. This natural process is caused by the dynamic activity of erosive agents, that is, water, ice (glaciers), snow, air (wind), plants, animals, and humans (FAO, 2015). In accordance with these agents, erosion is sometimes divided into water erosion, glacial erosion, snow erosion, wind (aeolean) erosion, zoogenic erosion and anthropogenic erosion. (Pinentel D et.all., 2013) Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing a serious loss of topsoil. The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality and damaged drainage networks. (Troeh FR *et al.*, 2004) Soil erosion could also cause sinkholes. Nutrients can be lost in a number of ways. Soluble nutrients like nitrate and potassium can be lost in runoff and drainage water, whereas less soluble nutrients like phosphorus are more likely to be lost with sediments moving in eroding soils and run-off water (Lal M, Mishra SK., 2015). Agricultural land use and management practices may affect soil properties, which play a critical role in sustaining crop production. A continuous process of soil and nutrient loss is going on all over the Hill soils under high rates of precipitation (Mandal UK *et al.*, 2012). The process is accelerated by the open cultivation system on steep to very steep land. In the greater district of CHTs, growing of Jhum crops in the hilly areas is causing extensive erosion. After a heavy rain even farmers question what has happened to the nutrients in their soils. (Bertol I *et al.*, 2003) This is important but it is not easy to assess how much nutrient has been lost because there are many variables to consider. We must be think about; the crop and the stage it is at; the applied fertilizer and the way it was put on; the soil, its texture and water holding characteristics. The intensity and duration of the rainfall even. Nutrient can be lost in a number of ways. Soluble nutrients like nitrate and potassium can be lost in run off and drainage water, whereas less soluble nutrients like phosphorus are more likely to be lost with sediments moving in eroding soil and run-off water. Negligible loss by wind erosion so organic matter, clay partials or soil in sand, silt, clay ratio is disturbed with reduce fertility.

Sloping farmland is an important resource, and also a major source of soil and water loss in Bangladesh. In recent years, with the increased use of sloping farmland and chemical fertilizer, soil and water loss and non-point source pollution on sloping farmland caused by agricultural activities are gradually coming into focus (Quan & Yan, 2002; Zhu *et al.*, 2005). In-depth systematic studies of the effect of tillage practices on soil erosion, nutrient loss, and crop growth under natural rainfall conditions could not only provide technical support for soil and nutrient loss control and agricultural non-point source pollution control and prevention, but also offer a theoretical basis to the forecast of land productivity and crop yields, which is of great significance.

Erosion removed the topsoil, which is the part of the soil containing the highest concentration of nutrients. Change of nutrient status was observed before and after heavy rainfall which caused plant nutrient depletion (Arif, M. *et al.*, 2007). There were appreciable differences in nutrient status between adoption of tillage practice and cover crop practices under Jhum rice. Under heavy rainfall, the nutrients in the surface soil were removed with the eroded soil along with runoff of water, in some cases rapidly leached and lost to the lower strata of the sailor to the groundwater (M. K. Gathala. *et al.*, 2015). The nutrient recycling chain is broken, and the released nutrients do not remain in the cultivated soil. A very important consequence of rapid disposal is the leaching of soluble nutrients. Losses of base cations (e.g. Ca, K and Mg) lead to soil infertility on one hand and rise in acidity/toxicity factors on the other (Arya, 1999). The result agrees with (Gafur *et al.*, 2000) who reported that runoff sediment lost from Jhum field contained 4 times higher nutrient than the original condition of the soil. Reduced OM might have led to the decreased water holding capacity of soil and favored acceleration of soil erosion (Khadka, S.R, *et al.*, 1987). Declining SOM in crop field also diminished the ability of soil to release nutrients in appropriate synchrony with crop demand (Maskey, r.B. *et al.*, 1992). A decline in SOM results in an inevitable decline in soil biological activity as well (Gruber, S. *et al.*, 2012). Thus, it revealed in the study that nutrient losses from soil erosion could be minimized through the use of cover crops.

Accelerated soil erosion has been an enduring problem since agriculture began (Atreya, K *et al.*, 2006). Out of ten major soil threats of the world, soil erosion is considered as the main one by the Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils. Soil erosion is a significant feature in several regions of Nepal, given the hilly topography and rugged mountains, concentrated rainfall events in the monsoon season, and increased human influence in the removal of natural vegetation and soil disturbance (Chalise, S *et al.*, 1997). Several research reports suggest that a significant amount of soil loss occurs in Bangladesh. From the experimental view following objective added:

- To determine the effect of tillage practices on soil and nutrient loss from slopping land of hills
- To estimate soil and nutrient loss as affected by soil and crop management

Materials and method

The experiments were done under the AEZ 29 (Northern and Eastern Hills Tract) during March 2016 to February 2017 in different hills of Bandarban in order to find cut the problems in Jhum cultivation and to develop some soil management technologies for improving the productivity of hill soils. Both field trials and laboratory analysis were done.

Soil and plant samples were analyzed in the Soil Science Laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur and Central Laboratory of Soil Resource Development Institute (SRDI), Dhaka. Ginger and turmeric are cultivated with deep tillage in the sloppy hills.

As a result, a huge amount of soils and nutrients are eroded every year. It is an alarming situation in the hilly areas of Bangladesh. Taking into account of this idea, this experiment was conducted at Hill Cotton Research Centre (HCRC), Balaghata, Bandarban to assess soil loss and calculate soil nutrient loss as affected by tillage.

Soil characteristics

The General Soil Type of the area was Brown Hill Soil under AEZ 29 (Northern and Eastern Hills). Soil morphological, physical and chemical characteristics of the experimental area are described in Tables respectively.

Table 1. Morphological characteristics of soil.

Characteristics	Description
Location	Balagata, Bandarban
Geographic position	22.13^{0}.061'N Latitude 90.12^{0}. 297'E Longitude 45 m height above sea level
Slope	44.5% Steep slope
Agro-ecological zone (FAO and UNDP, 1988)	Northern and Eastern Hills (AEZ -29)
General Soil Type	Brown Hill Soil
Soil Group	Suvolong
Parent material	Sedimentary rocks (Titan formation)
Drainage	Highly drained
Flood level	Above flood level
Land type	High land
Soil color	Brown

Table 2. Soil physical and chemical characteristics of soil (Mean value; n= 02).

Characteristics	Depth of soil	
	0-15 cm	15-30 cm
Texture	Clay Loam	Clay
pH	4.9	5.2
OM (%)	0.87	1.55
Exchangeable Ca (cmol/kg)	7.95	8.06
Exchangeable Mg (cmol/kg)	3.75	3.78
Exchangeable K (cmol/kg)	0.185	0.180
Total N (%)	0.044	0.078
Available P (mg/kg)	2.28	1.94
Available S (mg/kg)	1.61	1.37
Available Zn (mg/kg)	3.20	2.97
Available Mn (mg/kg)	4.19	4.80
Available Fe (mg/kg)	114	89.8
Available Cu (mg/kg)	0.56	0.55
Available B (mg/kg)	0.19	0.10

Treatments

The experiment was set up in Randomized Complete Block Design (RCBD) with three replications. The treatment details are given below.

Code	Treatments
T_1	No-tillage + No crop
T_2	Well-tilled soil + No crop
T_3	Well-tilled soil + Jhum crop
T_4	Minimum tilled soil + Jhum crop

Crop

Jhum crops were used in the experiment namely Jhum rice, marpha, sesame, maize, yard-long bean, sweet gourd, cowpea etc.

Experimental setup

Selection of research site

The site for this experiment was chosen at the hilly area of HCRC, Balaghata, Bandarban in consultation with the CDB authorities.

Climate

Bangladesh has a sub-tropical humid climate. Heavy rainfall occurs in the monsoon and scanty in the other seasons. The mean annual rainfall recorded at the Soil Conservation and Watershed Management Center (SCWM), SRDI, Bandarban, nearest to the experimental sites was 3010.9 mm and the annual average temperature was 31.63°C as maximum and 21.46°C as a minimum. Meteorological data like rainfall, temperature and relative humidity during the study period.

Initial soil samples

Before starting the experiment02 composite soil samples were collected from nine different spots from the surface (0-15cm) and sub-surface (15-30cm) parts of the soil. Soil samples were then processed for laboratory analysis to assess the relevant soil properties.

Slope percentage, elevation, longitude and latitude

Hillslope was measured by Abney Level. Elevation, longitude and latitude were determined by the GPS meter.

Land preparation

After selection of experimental sites, hill bushes and weeds were cleaned by cutting and burning. The individual plots were prepared by putting a one feet high tin fence surrounding each plot. This was done to restrict the transfer of water and eroded soil from outside of inside the plot and vice-versa. The dimension of each plot was 22 5 m^22. A pit having the size of 5×1 ×1m3 was made at the foot of each plot and wrapped by black polyethylene sheet for collecting erode soil.

Seed sowing and management practices

After preparation of all experimental plots, lands were tilled as per treatments and Jhum seeds were sown by adlibbing method on 05 June 2015. Fertilizers were applied as per famer's practice.

Intercultural operations and harvest

The experimental field was frequently monitored and necessary management practice such as weeding, pesticide application and earthening was done whenever required. The crop was harvested in the first week of May. The grain and straw yields and yield components were recorded.

Harvesting and eroded soil collection

Jhum crops were harvested on 14 October 2016 from the experimental field and brought them for processing in the Farmyard of HCRC, Balaghata, Bandarban. The eroded soil was collected from catch pit and calculated by Electric Balance on dry basis.

Yield and yield contributing data

After threshing and cleaning, crop yield and yield contributing data like plant height, number of panicles/m^2, length of panicle, number of grains/ panicle, number of filled grains/panicle, number of unfilled grains/panicle, grain yield/m^2, grain yield/ha, straw yield/ha and dry matter of other crops were collected in time.

Soil analysis

About 02 initial, 24 post-harvest soils and 12 eroded soil were collected, cleaned, and dried and stored for analysis. Methods for soil analysis are presented in section 3.1.4. Soil analysis includes pH, organic matter, total N, exchangeable K, Ca, Mg, Na, and available P, S, B, Mn, Zn and Cu contents.

Plant analysis

After harvest, plant samples from each pot were collected and divided into, straw and grain. The collected plant samples were then oven dried at 65°C for 24 hours.

To obtain a homogeneous powder, the samples were finely ground by using a Grinding-Mill to pass through a 60-mesh sieve.

Plant samples were digested with di-acid mixer (HNO_3: $HClO_4$ = 5:1) for determination of N, P, K and S concentrations following standard methods, as described below.

Table 3. Methods for analysis of plant samples.

Nutrients	Methods
N	Micro-Kjeldahl method (Bremner and Mulvaney, 1982): Plant sample was digested with conc. H_2SO_4 in presence of K_2SO_4 catalyst mixture (K_2SO_4:$CuSO_4$.5H_2O: Se=10:1:0.1). Nitrogen in the digest was estimated by distilling the digest with 10N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.
P	Digesting the samples in the di-acid mixture (HNO_3-$HClO_4$) and determined colorimetrically using molybdovanadate solution yellow color method (Yoshida *et al.* 1976).
K	Digesting the samples in the di-acid mixture (HNO_3-$HClO_4$) and determined directly by a flame photometer (Yoshida *et al.* 1976).
S	Digesting the samples in the di-acid mixture (HNO_3-$HClO_4$) and determined turbidity method using $BaCl_2$ (Chapman and Pratt, 1961).

Statistical analysis

Statistical analysis was done by 'Statistics 10'program. The mean effects were adjudged by LSD.

Result and discussion

Soil fertility in hilly areas is low due to acidic parent materials, erosion, runoff and nutrient leaching. Nutrient deficiencies need to be replenished through the addition of organic and inorganic fertilizers in a balanced way.

Part of the applied nutrients being taken up by crops but most of the remaining nutrients being lost through soil erosion causing environmental hazards such as soil and water pollutions (Sima, G. *et al.*, 2015). Qualitatively, soil fertility is considered as the most important factor in the cultivation viewpoint. Presently, soil erosion is accepted to be no less important than fertility as regard to environmental aspects. Soil erosion, which damages the base of plant growth and results in environmental pollution, ought to be reduced by soil conservation practices.

The practice of Jhuming affects the soil. Burning causes changes in the soil properties.

Burning chemically alters a portion of the plant nutrient supply from an organic form to a mineral form in ash, which is often readily soluble. When water runs over or passes through this ash, the soluble components are carried away and lost from the site in the form of run-off.

One year is quite insufficient to find any appreciable changes in soil fertility. The changes in soil parameters were more in the upper layer than that of lower soil depth. Reduction in organic carbon at the initial stage was observed by (Manna, M. *et al.*, 2007) in India and (Gafur *et al.*, and Thapa, G. *et al.*, 2002) in Bangladesh due to faster decomposition of litter owing to better soil tilth, favorable environmental conditions, and acceleration of microbial activities in the surface soil. However, OM and plant nutrients were much low in 15-30cm depth than that observed in the 0-15cm depth.

Soil loss

Soil loss under different tillage practices during the 2016-2017 is presented in Fig.. Soil loss under different tillage practices throughout the year was calculated on oven dry basis. The most apparent damage caused by water erosion is the removal of surface soil (Prosdocimi, M. *et al.*, 2016).

Fig 1. shows the distinct variation of soil loss due to different tillage practices in the hill. The highest soil loss (56.44 t/ha/yr) was recorded in T_2 treatment (well tilled, no crop) which was followed by T_3 (well tilled, Jhum crops) (39.62 t/ha/yr) and T_4 (minimum tilled, Jhum crop) (35.18 t/ha/yr). No significant difference was observed in soil erosion between the treatments T_3 and T_4.

The lowest erosion of soil (20.9 t/ha/yr) was noted in T_1 treatment where neither the tillage operation nor any cropping was done.

It reveals that the surface of sloping hilly land was subjected to the maximum disturbance through repeated tillage operations having no crops at the surface to protect the surface soil particles against raindrop beating.

In T_2, it has undergone easy dispersion of loose soil particles leading to the removal of soil with water from the uphill to the bottom. Even with repeated tillage in T_3 treatment, surface soil coverage by Jhum crops has led to a substantial reduction (30%) of soil erosion as compared to T_2. The treatment T_4 representing the Jhumia's practice, that is dibbling the soil (minimum disturbance of soil) for seed sowing and fertilizer application also led to a remarkable loss of surface soil (35.18 t/ha/yr) (Walkey *et al.*, 1934).

The soil under no-tillage & no crop in T_1 treatment remained undisturbed having surface natural vegetation by grasses and weeds protected the soil surface against exposure to direct hitting by raindrops or wind blow, resulting in the minimum loss of soil (20.9 t/ha/yr) (Sow, A.A., *et al.*, 1997).

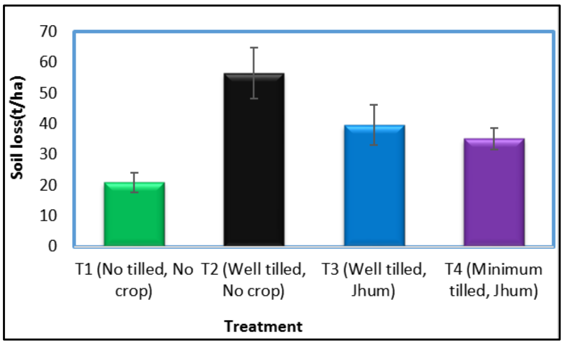

Fig 1. Soil loss (t/ha/yr) through erosion under different tillage practices.

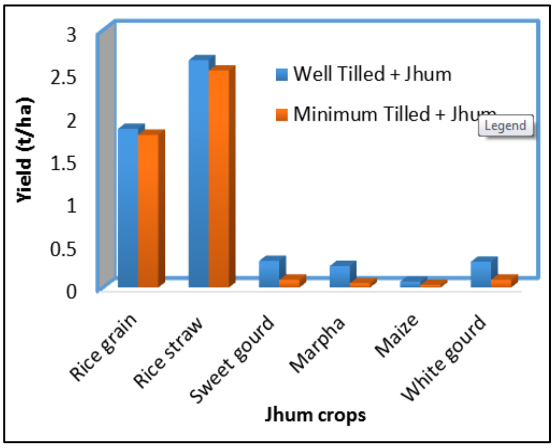

Fig 2. Effects of tillage practices on Jhum crops.

Nutrient loss

Chemical analysis of the eroded soils were done to compute the losses of different plant nutrients (N, P, K, Ca, Mg and S) and OM in kg/ha/yr. The maximum loss of OM (1371kg), N (79.6kg), P (0.14kg), K (3.1kg), Ca (36kg), Mg (20.5kg) and S (1.27 kg/ha/yr) were lost from hills subjected to repeated tillage operation in T_2 treatment. This remarkable loss of plant nutrients each year may result in the conversion of hill soils to barren land in the long run. On the other hand, due to minimum soil erosion in T_1 treatment (no tillage,no crop), the lowest amount of OM (839.9) and plant nutrients viz. N (38kg), P (0.14kg), K (1.88kg), Ca (15.5kg), Mg (8.43kg) and S (0.84 kg/ha/yr) had been lost through soil erosion. The results indicate that more the soil is disturbed or plowed down the more the soil and plant nutrients are lost from the hills (Havlin, J.*et all.*, 1990). A considerable amount of topsoil and nutrients had been lost over the year. In most cases, the intensity of nutrient loss through soil erosion was directly related to the amount of soil eroded from the hills. TreatmentT_2 (Well tilled, No crop) was subjected to the maximum soil erosion (56.4 t/ha/yr) and loss of OM (1371.5 kg/ha/yr), N (79.6 kg/ha/yr), Ca (36 kg/ha/yr), Mg (20.5 kg/ha/yr) and S (1.27 kg/ha/yr). The loss of P (0.14 kg/ha/yr) and K (3.08 kg/ha/yr) was a little bit lower than that recorded in treatment T_3 (well tilled, Jhum). In terms of the intensity of soil erosion and nutrient loss, treatment $T_2$was followed by treatment T_3. The soil and nutrient losses from T_3 were soil: 39.6 t/ha/yr; OM: (978.6 kg/ha/yr); N (62.2 kg/ha/yr); Ca (26.2 kg/ha/yr); Mg (14.83 kg/ha/yr) and S (1.00 kg/ha/yr) which were about 30, 29, 22, 27, 28 and 21 percent lower than that recorded in T_2 treatment in the respective parameters. Though, higher mineralization (loss) of OM (839.9 kg/ha/yr) was noted in T_1 plot (no tilled, no crop) as compared to T_4 (minimum tilled, Jhum) treatment, the loss of soil (20.9 t/ha/yr, 41% less) and plant nutrients such as N (38.0 kg/ha/yr, 25% less); P (0.14 kg/ha/yr, 29% less); K (1.88 kg/ha/yr, 38% less); Ca (15.5 kg/ha/yr, 29% less); Mg (8.43 kg/ha/yr, 13% less) and S (0.84 kg/ha/yr, 15% less) were considerably lower than that observed in treatment T_4 (Afshartous, D. *et al.*, 2010)

The highest soil erosion in T_2 treatment might be due to a maximum disturbance and exposure of topsoil had subjected the hill surfaces to undergo maximum dispersion and disintegration of soil particles of sloppy hills that led to the easy erosion of soil and nutrient depletion. On the other hand, treatment T_3 having the same tillage operations was covered by Jhum crops that had protected the surface soil against direct striking by severe raindrops that might have led to minimizing the soil erosion and plant nutrient depletion as compared to T_2 treatment. Soil and nutrient losses in T_1 treatment (no-tillage, no crop) were less as compared to T_4 (minimum tilled, Jhum crops) which might be due to no activity and disturbance of the topsoil and total coverage of hill surfaces by natural grasses and weeds that might have retarded the intensity of soil erosion and nutrient loss. On the contrary, minimum disturbance during dibbling at Jhum seeding in T_4 treatment had led to a minimum loss of soil and nutrients (as compared to T_2 and T_3 treatments), but it was higher than that found in T_1 treatment. It reveals from the data that hilly land having slopes in various degrees should be subjected to a various magnitude of disturbances. The soil should be covered by crops and any mulching material to protect the surface soil against direct contact of the raindrops and winds (Shan, Y.H. *et al.*, 2008).

Table 4. Effects of tillage practices on nutrient loss (Mean value, n=12).

Treatments	Soil loss (kg/ha)	OM and nutrient loss (kg/ ha/ yr)						
		OM	N	P	K	Ca	Mg	S
T_1: No tilled,no crop	20900	839.9	38.0	0.14	1.9	15.6	8.4	0.8
T_2: Well tilled, no crop	56440	1371.5	79.6	0.14	3.1	36.0	20.5	1.3
T_3: Well tilled, Jhum	39620	978.6	62.2	0.32	4.0	26.2	14.8	1.0
T_4: Minimum tilled, Jhum	35180	742.3	51.0	0.18	3.0	21.8	13.6	0.99

Table 5. Effects of minimum tillage on the reduction of soil erosion in relation to a well-tilled condition in the hilly area.

Treatments	Soil loss (t /ha)	Minimization rate over the tilled practice (t /ha)	The efficiency of conservation practices (%)
Well tilled, no crop	56.4	-	-
Well tilled,Jhum	39.6	16.8	30.0
Minimum tilled,Jhum	35.2	21.3 & 4.4	38 & 11.2

Economic value of nutrient loss by soil erosion

Present study exhibited that soil loss may be minimized to about 30-38% by adopting minimum tillage practice and Jhum crops (Table). It is important to note that 21.3t/ha/yr of soil loss, 28.6kg/ha/yr N loss, 0.04 kg/ha/yr Ploss, 0.06 kg/ha/yr K loss, 0.28 kg/ha/yr S loss, 14.19 kg/ha/yr Ca loss, 6.91 kg/ha/yr Mg loss can be saved by adopting treatment T_3 (minimum tillage, Jhum crop) instead of treatment T_2. As compared to treatment T_3 having well-tilled soil with Jhum crop, soil and nutrient losses were not so high compared to T_2, but there would be an appreciable loss of soil and nutrients as compared to treatment T_4 (minimum tilled, Jhum crops). It can be inferred that adopting minimum tillage (dibbling) for Jhum cultivation can save a considerable amount of soil resource at the sloppy land of hills.

Economic analysis of soil and nutrient loss from the hills reveal that good tilt results in considerable losses of soil and plant nutrients which may create an adverse environmental condition making the total hilly land unproductive in the long run. Table 5 exhibits the breakup of the loss resources in terms of taka/ha/yr from the sloppy hills due to well tilled practice. It has been estimated that a total amount of Tk. 34,548/- ha may be lost each year if the hilly lands are well tilled. Crop coverage though Jhuming may reduce the loss to some extent, but it should not be encouraged considering the consequences in the future. The minimum tillage, Jhum crops or any other commercial crops could be the best choice for the hill (Rai S, Sharma E s., 1998).

Changes in soil fertility

An assessment on the changes in chemical properties of soil over the year was made by analyzing soil samples at the surface (0-15cm) and sub-surface (15-30cm) layers of hills at the beginning of the study in 2016, and at the end in 2017 (Table 5) to find any changes (if any) in soil parameters. Though, one year is not enough to find any appreciable changes in soil fertility, it was observed that soil pH increased remarkably from 4.9-5.8 at 0-15cm depth and 5.2-6.0 at 15-30cm depth. Organic C content of soil after burning decreased from 2.46-1.56% at the surface (0-15cm) and 1.84-0.89% at the sub-surface soil layers. Similarly, percentage of total N in the soil was decreased in post-harvest soil from 0.14 to 0.10% at the surface and 0.12 to 0.08% at the lower layer. Soil P decreased from 3.28 to 2.62 mg/kg at the surface and 2.14 to 1.96 mg/kg at the lower layer of soil. The amount of exchangeable K decreased substantially after harvest, it being decreased from 0.19 to 0.08 cmol/kg at the surface and 0.18 to 0.07 cmol/kg at the sub-surface layers. Same trend was observed in case of S. Available S was declined from 13.18 to 10.21 mg/kg at the surface and 10.21 to 8.94 mg/kg at the sub-surface layer of hill soil.

Idle response of tillage practice

Influence of tillage on yield and yield contributing characters of Jhum rice is presented in Fig 2. Tillage practices created a very positive effect on the yield of Jhum. The maximum yield of Jhum rice was produced under well-tilled treatment (1.85 t/ha). The lower yield of Jhum rice was produced in the minimum tilled plot, with Jhum crop grown. Similar response was found in case of straw yield. About 2.65 t/ha straw yields were found in well tilled practice whereas it was 2.53 t/ha in minimum tilled.

Tillage practice favored the yield of Jhum crops including rice, sweet gourd, marpha, maize and white gourd. The dominating crop rice was produced only 4% higher yield under the well-tilled soil (1.85 t/ha) as compared to 1.78 t/ha of rice grain obtained under minimum tillage practice. Rice straw yield also followed the same trend as was observed in rice grain. The higher yield of sweet gourd (0.31t/ha) was produced under the well-tilled condition, which was 244% higher than that recorded in the minimum-tilled plot. Marpha yield (0.25 t/ha) was higher in well-tilled condition as compared to yield (0.05t/ha) noted under minimum tilled practice.

Table 6. Effects of conservation tillage and Jhum cultivation on soil and nutrient avings in the hilly area (Mean value, n=3).

Categories	T_2: Well tilled, no crop	T_3: Well tilled, Jhum	T_4: Minimum tilled, Jhum	Saving resources in T_4 against T_2& T_3
Soil loss (t /ha)	56.4	39.6	35.2	21.3& 4.44
Nutrient loss (kg/ ha)				
N	79.6	62.2	51.0	28.6& 11.2
P	0.14	0.32	0.18	-0.04 & 0.14
K	3.08	4.02	3.02	0.06 & 1.00
S	1.27	1.00	0.99	0.27 & 0.01
Ca	36.0	26.2	21.8	14.2 & 4.4
Mg	20.5	14.8	13.6	6.91 & 1.28

Maize yield (0.07 t/ha) in well-tilled soil was 133% higher than that observed in minimum tillage. Similarly, a higher yield of white gourd (0.3 t/ha) in well-tilled soil was 233% higher than that found in minimum tilled the soil (0.09 t/ha).

Table 7. Cost of soil and nutrient loss under well-tilled practice.

Classification	Total loss	In terms of chemical fertilizers	Cost of fertilizer and equivalent loss (Tk.)
Soil loss (t/ ha)	56.4	-	28,220/-
Nutrient loss (kg /ha)			
N	79.6	173.02 kg Urea	2768/-
P	0.14	1.0 kg TSP	22/-
K	3.08	6.16 kg MoP	100/-
S	1.27	7.94 kg Gypsum	50/-
Ca and Mg	56.5	282.3kg Dolochun	3388/-
Sub-total (Tk/ ha)	-	-	6,328/-
Total (Tk/ha)	-	-	34,548/-

The rate of Fertilizer: Urea Tk. 16.00/kg, TSP Tk. 22.00/kg and MoP Tk.16.00/kg, Dolochun Tk.12.00/kg* = A unit cost of soil dressing: Tk. 500.00/ton. C.F = Commercial Fertilizer

Table 8. Changes in pH and nutrient status of soil collected from Balaghata, Bandarban (Mean value, n=3).

Soil parameters	Initial soil status before tillage		Post-harvest soil status	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Soil pH	4.9	5.2	5.8	6.0
Organic Matter (%)	2.46	1.84	1.56	0.89
Total N (%)	0.14	0.12	0.10	0.08
Available P (mg/kg)	3.28	2.14	2.62	1.96
Exchangeable K (cmol/kg)	0.19	0.18	0.08	0.07
Available S (mg/kg)	13.18	10.21	10.21	8.94

The above findings indicate that even with insignificant higher yield (4%) of dominating Jhum rice in well tilled, Jhum plot, this treatment cannot be accepted owing to higher losses of soil and nutrients if cultivated continuously for a long time.

Conclusion

Soil loss under different tillage practices during the 2016-2017 year was calculated on oven dry basis. The most apparent damage was caused by water erosion is the removal of soil from hill surfaces. It might be due to a direct hit of the rain splash on the topsoil in tilled treated plot and accompanied by surface runoff of water carrying the soil particles away in the downwards direction along the hill slopes. Whereas, raindrops could not hit ground surfaces covered by natural vegetation, which slowed down the force of raindrops. Those were not within the tolerable range. They assigned soil loss tolerances ranging from 4 to 13 t/ha/yr. This general range of tolerable losses was accepted by the 'Soil Conservation Services' (SCS) research officers of United States (US), but later it was agreed that 11 t/ha/yr should be the maximum rate and that there were some soils so fragile that a rate of only 2 t/ha/yr should be added. According to the soil loss tolerable range, crop combination with mulch should be encouraged for reducing soil erosion.

The amount of nutrient loss from the hills is directly related to the amount of soil eroded from the hill surface. So, the trend of nutrient losses under different tillage treatments is similar to that of eroded soil. The removal (losses) of total N, available P, and available S were remarkably higher in treatment 2 (well tilled with no crop) over the treatments number 1, 3 and 4 where the land surfaces were covered by natural vegetation, well tilled with Jhum rice and minimum tilled with Jhum rice, respectively. Of course, hillslope and hill length are important factors in regulating the intensity of soil and nutrient losses from hills. Minimum disturbances of soil surface along with suitable crop coverage may result in retardation and minimization of soil and nutrient losses from hills. In addition, regular addition of balanced fertilizer along with organic residues may lead to improve soil health and attain higher sustainable productivity. Live surface vegetation, providing high contact cover, managed to keep soil loss low. Substantial erosion occurred only during torrential rain period. Jhum rice as a cover crop could exploit the top soils which are not badly eroded under vegetative surface cover.

Though tillage practices increase soil loss from the hill, it is also proven that tillage has been playing an important role in agriculture, particularly in food production. Tillage has various physical, chemical and biological effects on the soil both beneficial and detrimental.

The physical effects such as aggregate-stability, infiltration rate, soil and water conservation, in particular, have a direct influence on soil productivity. Deep plowing is superior to non-tillage in increasing plant-available water and crop yields. Similar data showing better responses of tillage than no tillage or greatly reduced tillage on a variety of soils. Tillage practice increased the yield of associated Jhum crops like a sweet gourd, marpha, maize and white gourd. Though tillage accelerates soil erosion in the sloppy hilly land, it also favors growth and yield of crops by providing more rooms for root growth to extract more nutrients and moisture from the soil. It decreases weed infestation as well.

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