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Effect of varying slopes on soil loss from newly planted tea in North Eastern India

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Abstract

Tea grows on different slopes in North Eastern India. Varying intensity and duration of rainfall result in considerable soil loss, which has not been documented so far. Experiments were conducted during 2009 at the Tocklai Experimental Station of Tea Research Association, Jorhat, Assam (India) to monitor the periodical changes in soil loss from a newly established tea area with different rainfall intensities, duration and amount under varying degrees of slope (0.1, 2, 3 and 6 percent). The study revealed that an increase in the rainfall intensity, amount and duration in general, increased the soil loss in all treatments. An increase in the soil loss was recorded with the increase in slope per cent. The comparative soil loss, however, decreased with the advancement of crop/ increase in number of days after planting. The average soil loss per mm of rainfall under 0, 1, 2, 3 and 6 per cent slopes was found to be 2.65, 17.14, 34.91, 39.89 and 47.26 kg ha^{-1}. The estimated average annual soil loss from these slopes was 5.37, 34.71, 70.70, 80.79 and 95.73 t ha^{-1} year^{-1}, respectively. The trend of soil loss was highly correlated with the soil slope having R^2 value of 0.9

Keywords: *Rainfall , Soil erosion, Soil loss, Tea*

Introduction

Among other components, soil is considered to be one of the most important factors for crop cultivation. Protection of the soil from erosion in the initial years of tea growth is crucial while in mature tea the compact canopy offers fairly satisfactory ground cover. In a tea garden for identical slopes the maximum soil loss is from plots with newly planted tea with inadequate soil cover (Samraj *et al*., 1980). The steeper the grade, the more will be the velocity and discharge for the same cross-sectional area of the drain, but excessive grade produces very high velocities which cause erosion (Singh, 1979). With age and increase in the canopy of the tea bushes, both run-off and resulting soil wash are considerably reduced. Proper catchment planning and various soil conservation measures like contour planting, contour drains, contour bunds, raising green crop, mulching, strip weed control and drop structures etc. are important for erosion prone areas (Bordoloi and Goswami,1996; Chakravartee and Barpujari, 1996). The problem of soil erosion in tea gardens is higher in sloping lands than in plains. The planting of tea on steep slopes, therefore, posses the soil erosion problem of special nature. It is reported that more than 30 cm of valuable fertile top soil has lost through soil erosion by water in Darjeeling tea estates in North Eastern India. This amounts to about 3 to 4 mm of soil wash every year which is a very high figure. There are several hill slopes now without any top soil and, hence the tea plantation has been abandoned in those areas (Singh, 1984). Goswami *et al.* (1997) reported a soil loss of 4 to 58 tonnes/ha and 98 to 172 tonnes/ha from different sites depending on the slope, soil type and the extent of soil cover. The trend of soil loss closely followed the rainfall pattern. Significant quantities of essential nutrients were also lost with the eroded soil. In North East India 70 percent of the total rain is received in the months of May-August and this period receives most of the erodable rain. Keeping this in view a study was carried out with the objective of assessing the soil loss from varying percentage of slopes in a newly planted tea area.

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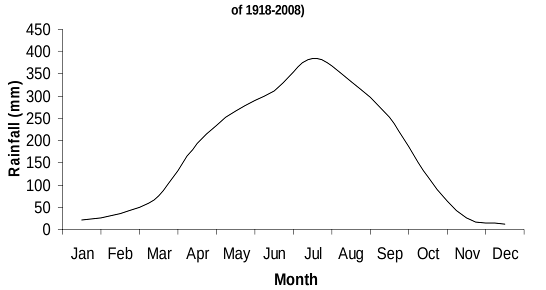
Materials and Method

The experiments were conducted at the Tocklai Experimental Station of Tea Research Association, Jorhat, Assam (India) in the year 2009. The research farm lies at 26^O 47' N latitude and 94^O 12' E longitude at an elevation of 96.5 m above mean sea level and comes under humid sub tropic zone. Annual average rainfall of the place is 2025.5 mm. The monthly distribution of rainfall for the last 90 years is given in Fig. 1. The monsoon rains start from mid April and withdraw in mid October. About 86 per cent of annual rainfall is received during this period only, whereas post rainfall contributes about 6 per cent. Winter rains are meager and account for only 8 per cent. The soil texture of the experimental site was sandy loam with a bulk density of 1.31 mg m^{-3} and a pH value of 5.50. The experimental plots with five varying slopes having a magnitude of 0, 1, 2, 3, and 6 per cent were constructed artificially to estimate the soil loss. The loss of soil after the occurrence of rainfall event was collected at the entry point of cement concrete tank constructed at the end of the plot. The amount of soil present as suspension in the tank was also accounted for calculating soil loss. The rainfall duration and intensity were calculated from the meteorological data recorded from the met station situated in the experimental area itself. One year old tea saplings, clone TV-23, were planted on June 17, 2009. The tea was grown under natural conditions without any shade.

Fig. 1: Average annual rainfall (mm) of Tocklai Experimantal Station (average of 1918-2008)



Results and Discussion

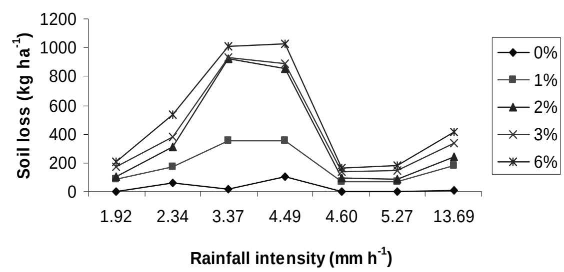
A perusal of the data on soil loss indicated that an increase in the rainfall intensity, amount and duration in general, increased the soil loss in all treatments. Also an increase in the soil loss was recorded with the increase in slope percent. The comparative soil loss, however, decreased with the increase in the number of days after planting.

The observations recorded after 58 days of planting revealed that the soil loss decreased as the crop growth advanced and the comparative impact of increasing rainfall intensity and duration, decreased with the increase in the age of plants after this period. This could be attributed to relative establishment of tea roots in the soil, binding of soil particles and stability of the aggregates in the soil over time. The establishment was more pronounced in relatively flat land (0% slope) and decreased with the increase in slope. The crop might have established themselves earlier and better in plots with 0% slope than under higher slopes. This effect could be ascribed to higher velocity of the run off water on the surface of sloping plots than the relatively flat plots. Also, infiltration of water in flat lands is higher as compared to that of plots having higher slope, where water flows over the surface with high velocity as a result of difference in gradient.

Rainfall intensity *vs.* soil loss

The soil loss under different rainfall intensities (RI) and slopes is given in Fig. 2. Under all the treatments, higher soil loss was observed when the rainfall intensity (RI) was 4.49 mm h^{-1} followed by RI of 3.37 mm h^{-1}. Among different treatments higher soil losses of 851.42, 892.64 and 1025.12 kg ha^{-1} under RI of 4.49 mm h^{-1} and 926.48, 934.73 and 1009.82 kg ha^{-1} under RI of 3.37 mm h^{-1} were observed under 2, 3 and 6 per cent slopes, which was comparatively low (105.48, and 352.83 kg ha^{-1} under RI of 4.49 mm h^{-1} and 19.06 and 350.20 kg ha^{-1} under RI of 3.37 mm/h) under 0 and 1 per cent slope, respectively. The higher soil loss under these two RIs can be attributed to higher corresponding rainfall duration of 22.92 and 15.17 hours, respectively. The higher rainfall duration under these two RIs provided ample time to beating and washing action of falling raindrops on the soil surface which increased with the increase in slope. The soil loss under steeper slopes is also higher because of low water infiltration under increasing slopes especially when the RI is high. Dey (1969) reported that rapid infiltration of rain water was necessary to minimise loss of soils through erosion and can be achieved more easily in flat tea lands or where soil erosion management practices are followed.

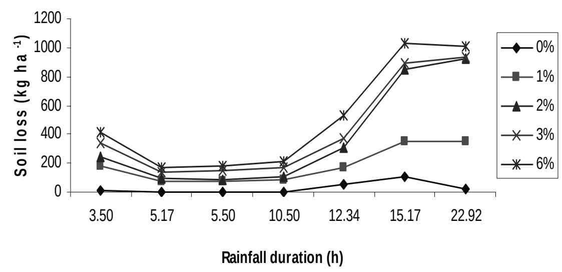
Fig. 2: Effect of rainfall intensity on soil loss from a newly planted tea garden under varying slopes



Rainfall duration *vs.* soil loss

The effect of rainfall duration on soil loss under varying slopes shows that in all the treatments, a rainfall of 3.50 hours duration yielded higher soil loss over rainfall episodes of 5.17, 5.50 and 10.5 hours duration (Fig 3). A rainfall event of 3.50 hours duration after 66 DAP with an average RI of 13.69 mm h^{-1} resulted in higher soil loss than a rain of 5.17, 5.50 and 10.5 hours duration having 4.60, 5.27 and 1.92 mm h^{-1} RIs, indicating that the former rainfall duration (3.50 hours with RI of 13.69 mm h^{-1}) was more intense to cause higher soil losses. However, rainfall duration of 15.17 and 22.92 hours duration in the initial stages of crop establishment *i.e.*, 54 and 58 DAP, respectively, caused higher soil loss under 2, 3 and 6 per cent slopes than under 0 and 1 per cent slopes.

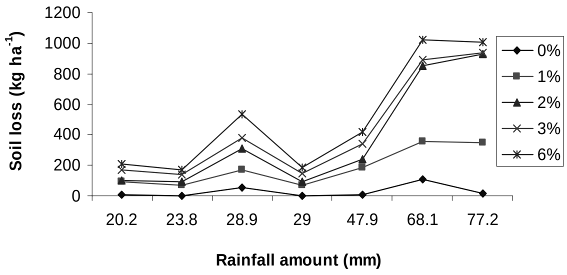
Fig. 3: Effect of rainfall duration on soil loss from a newly planted tea garden under varying slopes



Rainfall amount *vs.* soil loss

The amount of soil loss with the amount of rainfall received showed that under all the treatments, the soil loss increased with the increase in slope at all the quantities of rainfall receipt. In 0 percent slope, rainfall amount of 20.2, and 23.8 mm resulted in lesser soil loss (3.92, 3.57 and kg ha^{-1}), than 47.9, 68.1 and 77.2 mm rainfall where the soil loss was to the tune of 7.23, 105.48 and 19.06 kg ha^{-1}, respectively. The soil loss was much higher under 2, 3 and 6 per cent slopes at rainfall amount of 68.1 and 77.2 mm because of early stage of crop and soil establishment (54 and 58 DAP), wherein under increasing slopes, the soil was more vulnerable to the impact of rainfall. Goswami *et al.*, (1997) also observed that the trend of soil loss closely followed the rainfall pattern from young tea fields on Cachar teelas.

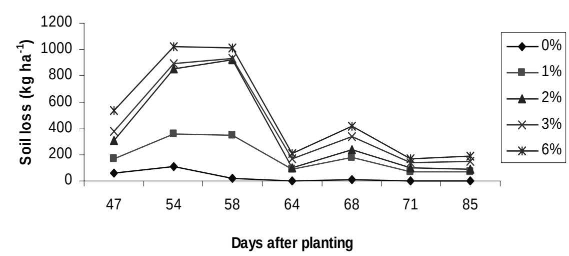
Fig. 4: Soil loss (kg ha^{-1}) from a newly planted tea garden during different rainfall episodes under varying slopes



Days after planting *vs.* soil loss

In general, except for 54 and 58 days after planting (DAP) of tea crop, where rain duration was higher to cause higher soil loss, there was a decrease in soil loss under all the treatments, with the advancement of the crop (Fig. 5). However, among different slopes, the soil loss increased with the increase in the degree of slope. The reason for the reduction of soil loss over time is that the binding of soil particles by plant roots over time might have resulted in the lesser soil loss with increased DAP in all the treatments. The results were found to be in confirmation with Samraj *et al*. (1980).The soil loss under different slopes over

Fig. 5: Soil loss (kg ha^{-1}) from a newly planted tea garden under varying slopes



time was also calculated under a condition when the soil was receiving a uniform rainfall of 1mm with rainfall intensity of 1mm h^{-1} for one hour (Fig 6). It can be established that with the advancement of crop, the soil loss also decreased under all the treatments.

Average annual soil loss from young tea garden
From the different rainfall episodes it can be 2025.5 mm, that on an average, the soil loss per mm of rainfall receipt under 0, 1, 2, 3 and 6 per calculated for newly established tea garden in Jorhat area, where the average annual rainfall is cent slopes would be 2.65, 17.14, 34.91, 39.89 and 47.26 kg ha^{-1} and average annual soil loss from these slopes would be 5.37, 34.71, 70.70, 80.79 and 95.73 t ha^{-1} $year^{-1}$, respectively (Table 6). The trend of soil loss was highly correlated with the soil slope having R^2 value of 0.95 (Fig. 7).

Fig. 6: Soil loss (kg ha^{-1}) from a newly planted tea garden receiving uniform rainfall of 1mm with rainfall intensity of 1mm h^{-1} under varying slopes

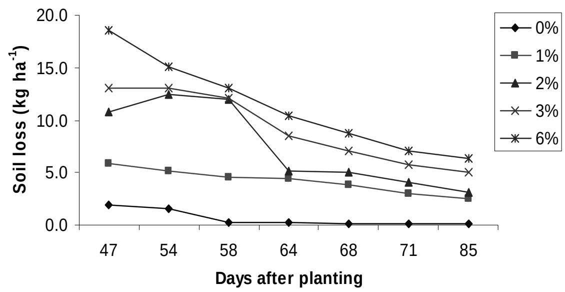


Fig. 7: Annual average soil loss (t ha^{-1} $year^{-1}$) from a newly planted tea garden under different slopes

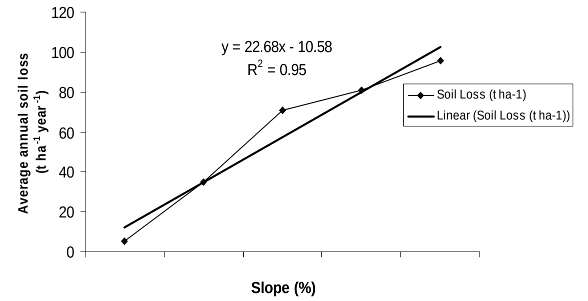


Table 6: Average soil loss (kg ha^{-1}) from a newly planted tea garden under varying slopes

Particulars	Slope (%)				
	0	**1**	**2**	**3**	**6**
Average rainfall (average of seven episodes)received during experimental period: 10.73 mm					
Soil loss (kg ha^{-1}) with 10.73 mm rainfall	28.45	183.87	374.48	427.92	507.03
Average loss (kg ha^{-1}) per mm of rainfall	2.65	17.14	34.91	39.89	47.26
Annual average rainfall of the experimental site: 2025.5 mm					
Average annual loss t/$ha^{-1}$$year^{1}$	**5.37**	**34.71**	**70.70**	**80.79**	**95.73**

Conclusion

Soil loss increased in the early stages of the tea as well as increase in soil slope. The increase in rainfall intensity increased soil loss with the increase in slope. Flat soil with zero slope had the minimum soil loss. The necessary steps should be taken to reduce the soil loss by contouring, bunding, erosion control devices etc. as early as possible in the newly established tea garden. A huge quantity of soil loss, as is evident from the data generated from the current experiment, can be avoided, thus, helping in maintaining the environment sustainability by conserving the soil.

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