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Soil Loss and Runoff Measurement From Banana-Pineapple Intercroping System

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Abstract

In the two distinctive seasons, first from March to May and second from September to November, rainfall in these months was very high as compare to other months. Rainfall distribution during the experimental period was about 25 percent higher than the average monthly rainfall of the last 10 years. Soil loss and runoff was more during the early four months of the crop establishment after which it was reduced gradually due to the establishment of canopy cover of the plants. There was a significant linear relationship among soil loss and runoff with EI_{30} index for all the plots. Total soil loss during the experimental period was 105.6 tons ha from bare plot, 40.1 tons ha^{-1} from banana plot; 26.4 tons ha^{-1} from intercrop of banana-pineapple and 25.0 tons ha^{-1} from pineapple plot. Soil erosion can be controlled to a greater extent by a number of soil and crop management practices as well as by selection of proper cropping system for sloping agricultural lands. Proper crop selection in itself is an important mean of controlling soil loss and runoff from the field. Intercropping of banana with pineapple is a good practice for controlling long term soil loss and runoff from the sloping agricultural lands. It involves less crop and soil management practices as compared to annual crops. Banana when planted as an intercrop can give some economic benefits to the farmers when other crops are not mature whereas pineapple crop will have significant effects in reducing soil loss and runoff from the sloping lands.

Introduction

Intercroping is the growing of annual or short term crops with the main crop through out the life of plantation. Planting of many annual crops like soybean, groundnut, tobacco, maize, sorghum and vegetables as intercrop between rubber and oil palm has increased the risk of severe soil erosion in the agricultural land of Peninsular Malaysia. These crops require more cultural practices that enhance the removal of top layer (Soong *et al.*, 1980). Most of work on intercroping carried out in Malaysia is in connection with cultivation of two major perennial tree crops, rubber and oilpalm. However, the results obtained and the principles established are also applicable to other crops.

The intercrops are selected for their efficiency in controlling soil erosion and for their beneficial influence on the growth and yield of major crop. Due to their differences in density and morphology, plants differ in their ability to protect the soil. Generally, rowcrops are the least effective and give rise to more serious erosion problems. Creeping legumes on the other hand have been found to be efficient cover plants, both from the stand point of erosion control and crop improvement but their influence is not permanent. After tour to five years from establishment these legumes die off, as a result of shading effect from the canopy of the tree crops (Soong *et al.,* 1980). In addition to crop selection, other factors such as plant population, time of planting and fertility levels also influence the amount of erosion. The combination of annual crops with medium term crops such as papaya was not suitable as the yield of the annuals decrease tremendously due to the shading effect of the papaya tree (Mokhtaruddin *et al.,* 1991).

Therefore a new intercropping system of banana with pineapple was practiced for the control of soil loss and runoff from sloping lands. As these crops are perennial which require less soil and crop management practices and their effect on erosion is also for a longer period as compare to annual crops.

Materials and Methods

Study area and experimental method: The experiment was conducted at Puchong Farm, Universiti Putra Malaysia (UPM). The slope of the area ranges from 8 to 10 percent. Four plots of same length with different width were prepared. Plot size for bare and pineapple was 55.25 m^2 and for banana and intercrop plot was 110 m^2.

The soil under study is classified as Bungor series (*Typic paleudult*) under the Kaolinitic family. It is dark yellowish brown (10YR 4/4) to light olive brown (2.5Y 5/4) in colour (Lau, 1995). Its texture as a whole is sandy clay loam with a consistence that changes from friable to firm with depth. The experiment was carried out to study the effectiveness of banana and pineapple intercrop on soil erosion. Soil loss and runoff was measured for a period of nine months (August 1996 to April 1997). Each plot was isolated hydrologically with planks (25 cm wide) along each side to a depth of at least 15 cm to prevent leakage of surface runoff from the plots. The bare plot was ploughed along the slope twice a week to achieve maximum soil structure interference and weed free condition.

Planting of banana and pineapple: The banana suckers of Rastali *(Musa paradisiaca)* were planted at a planting distance of 2.4 m row to row and plant to plant distance. Fertilization of banana plant was done at the rate of 100 kg N, 90 kg P_2O_5 and 130 kg K_2O per hectare (Idris, 1990)

using Urea, Triple Super Phosphate (T5P) and Murate of Potash (MOP).

The suckers of pineapple *(Ananas comosus)* cultivar of Sarawak was planted in triangular planting of three rows at a planting distance of 0.6 m plant to plant and row to row. The crop was planted in hedgerows of three rows of pineapple in each hedge with a distance of 1.5 m between the hedges. Fertilization of pineapple plants was done at the rate of 500 kg N, 250 kg P_2O_5 and 840 kg K_2O per hectare (Wee and Tay, 1980) using. Urea, TSP and MOP. Planting densities in intercrop, banana and pineapple plots were 9865, 1448 and 16652 plants per hectare respectively.

Runoff and soil loss data collecting system: At the end of each plot there was runoff collecting trough made of sheet iron and was placed at similar gradient as the plots. A pit was dug at the lower end of each plot. The space of the pit was big enough to put the sedimentation tanks inside it and to allow sampling and cleaning work to be carried out. Sediment and runoff water from the plots was delivered to a series of sedimentation tanks, which were placed below the out let of the collecting trough. Secondary sedimentation tanks placed behind the primary sedimentation tanks were used to collect the runoff overflow from the primary sedimentation tanks. All the tanks were calibrated to get the volume-depth relationship for runoff water. Runoff volume and sediment loss was collected after every erosive rainfall. Samples of two litres each from every tank were collected in bottles from uniform slurry in the tank. Runoff volume was calculated using the volume-depth relationship of each tank. Sediment concentration was determined by drying a 100 ml of aliquot from each sample on a steambath until a constant mass was obtained. After that the sample was cooled and weighed, soil loss was calculated on hectare basis.

Rainfall was recorded from the weather station near the experimental site. The amount of rainfall, duration and intensity of each erosive rainfall event was calculated from the casella rainfall chart. Rainfall erosion indices (EI 30 in M.J mm/ha-hr) was calculated using the kinetic energy of following rain multiplied its maximum 30 minutes intensity.

Results and Discussion

Rainfall distribution: The average monthly rainfall record of experimental area shows two distinctive rainfall seasons. The first peak is during March to May, which is less intense than the second from September to November. The monthly distribution of rainfall during experimental period was compared to 10 years average monthly rainfall distribution (Table 1). It shows that the monthly rainfall, except for November and March, was more than average monthly rainfall of 10 years. Total rainfall during the experimental period of August 96 to April 97 was about 25 percent more as compared to the mean average rainfall of previous 10 years. Due to which weather remain relatively more wet during the entire experimental period and therefor more soil loss and runoff was expected from the experimental site.

Among the total of 127 rainfall events during th experimental period only 64 were recorded as erosion rainfall events (Table 1) that contributed to 80 percent of the total rainfall amount. Total rainfall during the experimental period was 2020 mm out of which 1777 mm was erosive which created an erosion index (EI_{50}) 18861.5 Mjmm/ha.hr.

Runoff and soil loss: Table 2 shows that there was almost no difference in soil loss between the plots for the first two months (August and September). This was mainly due to ploughing and planting of the fruit plants which created similar structure and roughness condition of the ploting whereas in the month of October soil loss was highest from pineapple plot and lowest from bare plot. This could be due to more disturbance of pineapple plot during planting followed by extremely high rainfall (406.2 mm) in th month of October 96. After that there was a gradually decrease in soil loss from the crop plots as compare to basic plot. This was only possible due to the establishment crop canopy that prevented the raindrops from following directly on the ground and thus reducing the soil loss from the surface. The total soil loss from bare, banana, intercrop and pineapple plots was 105.6, 40.1, 26.4 and 25.0 for ha^{-1}, respectively. The order of soil loss from the plot during the entire experimental period was; bare > banana intercrop > pineapple.

When runoff from the plots was compared, it showed the there was no significant difference in runoff from the plot for the first two months. In the month of October while rainfall was highest (406.2 mm) as compared to the other months, runoff from banana plot was maximum (2.7 x 10 Lit/ha). After that there was gradual reduction in runoff from the banana plot due to establishment of crop canope which provide sufficient protection to the surface again the heavy raindrops. Total runoff from banana plot was 9×10^6 Lit ha^{-1}. The runoff from bare plot was different each month because it was cultivated fortnightly due which the infiltration rate and roughness condition of soil was improved causing in less runoff from the plot for the rainfalls that followed immediately after cultivation. But the month of December, January and April the runoff from the bare plot was very high due to more erosive rainfalls these months.

Total runoff from bare plot was 11.1×10^6 Lit ha^{-1}. Whereas in case of intercrop plot there was a significant difference in runoff as compared to banana and bare plot. The intercrop plot had less runoff as compare to these plot due to more canopy and ground cover provided by banana and pineapple plants from the month of December to April Total runoff from intercrop plot was 6.3×10^6 Lit ha^{-1}. Pineapple plot experienced high runoff for the firsts months after which there was gradual reduction in runoff due to establishment of plants which acted as hedgerover

Table 1: Monthly rainfall distribution of experimental area

Months	Total rainfall (mm)	Average rainfall (mm) (1986-95)	Total erosive rainfall (mm)	Total rainfall events (No.)	Total erosive events (No.)	Erosion index (E130)
August 96	217.9	105.9	135.5	14.0	5.0	1085.1
September	193.3	177.2	175.2	7.0	2.0	1387.2
October	406.2	181-.4	392.5	21.0	15.0	3431.3
November	188.3	255.6	173.7	14.0	8.0	1630.7
December	290.6	174.8	280.1	16.0	11.0	3521.8
January 97	197.4	123.4	180.4	9.0	5.0	2862.7
February	183.8	109.1	150.8	16.0	5.0	1907.5
March	84.0	219.9	64.7	11.0	4.0	176.1
April	258.9	196.4	224.8	19.0	9.0	2858.9
Total	2020.4	1543.7	1777.7	127.0	64.0	18861.3
Mean	224.5	171.5	197.5	14.11	7.11	2095.7

Table 2: Soil Loss and Runoff from the experimental plots

Months	Soil Loss (m.tons/ha)				Runoff ($x10^3$ Lit/ha)			
	Bare	Banana	Intercrop	Pineapple	Bare	Banana	Intercrop	Pineapple
August 96	1.8	0.6	1.2	1.2	204.2	132.0	150.1	226.5
September	3.0	0.8	1.5	1.6	260.8	169.2	191.4	288.5
October	5.4	8.9	11.1	14.2	1400.0	2685.5	1841.7	1800.6
November	4.0	3.7	3.1	2.7	832.3	831.7	827.6	1298.4
December	13.0	6.2	4.0	2.8	2595.7	2071.3	1417.9	1789.5
January 97	24.4	5.3	4.3	1.9	2576.2	1439.0	1019.6	1315.4
February	11.5	3.2	0.2	0.3	425.8	547.3	128.1	246.7
March	1.3	0.2	0.0	0.0	132.4	128.8	8.0	0.0
April	41.2	11.2	1.0	0.3	2688.8	1291.3	738.8	258.3
Total	105.6	40.1	26.4	25.0	11116.2	9296.1	6323.2	7223.9
Mean	11.7	4.5	2.9	2.8	1235.1	1032.9	702.6	802.7

against the surface runoff. Pineapple crop takes long time to establish due to its slow growing habit which resulted in more runoff and soil loss from the plot in the early stage of growth. Total runoff from pineapple plot was 7.2 x 10^6 Lit ha^{-1}. The ratio of total runoff during the study period was 32.74 percent from bare plot followed by 27.37 percent from banana, 21.27 percent from pineapple and 18.62 percent from the intercrop plot. The order of runoff, from the plots was different as compare to soil loss from these plots i.e. bare> banana >pineapple >intercrop.

Difference of soil loss and runoff from cropped plots was not much during the first three months of crop establishment as compared to bare plot. Because the crop was not sufficient to protect the surface against the heavy rainfall due to which there was more detachment and transportation of soil particles. But after three months of crop establishment canopy cover of the plants were grown enough to reduce the soil loss as compared to bare plot. Even the EI_{30} was much higher as compare to early three months. Low soil loss and runoff from the cropped plots, may also be due to establishment of root network of the plants which open up the soil and enable water penetration and thereby increasing infiltration capacity of the soil (Morgan, 1979). The root system can also physically bind the soil particles together into stable soil aggregates and thus reduce the rate of runoff (Soong *et al.*, 1980).

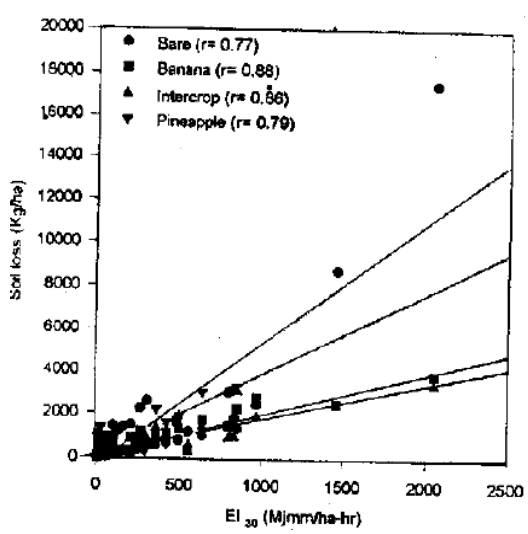

Fig. 1: Relationship of EI_{30} with soil loss.

Relationship of EI_{30} with soil loss and runoff: Relationship of with soil loss and runoff were examined by linear

regression analysis for all plots. The simple linear regression gave a correlation coefficient of 0.77, 0.88, 0.86 and 0.79 for bare, banana, intercrop and pineapple respectively when EI_{30} was analyzed with soil loss from different plots. It showed that simple linear correlation coefficients were highly significant at 1 percent probability level for ail the plots. This high correlation coefficient indicates that EI_{30} index and soil loss is highly associated with one another in a linear way. The higher the EI_{30} value more will be soil loss from the plots (Fig. 1).

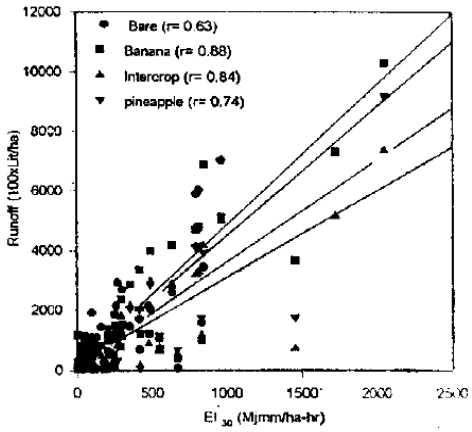

Fig. 2: Relationship of EI_{30} with runoff.

When the relationship between EI_{30} index and runoff from the plots was examined the simple linear regression gave a correlation coefficient of 0.63, 0.88, 0.84 and 0.71 for bare, banana, intercrop and pineapple respectively. Simple linear correlation coefficient for all the plots were highly significant at 1 percent probability level. This also indicated that there is a strong association between EI_{30} index and runoff from the plots (Fig. 2). The high erosivity of rainfall will create more soil loss and runoff from the plots. Therefore it can be assumed that EI_{30} is a valid rainfall erosivity index for the experimental site.

Relationship between soil loss and runoff: The amount of soil loss from the field was correlated with the corresponding amount of runoff from the plots. The relationship of soil loss with runoff was also examined by linear regression analysis. The simple linear regression gave a correlation coefficient of 0.56, 0.82, 0.88 and 0.53 for bare, banana, intercrop and pineapple plots respectively. Simple linear correlation coefficient was highly significant at 1 percent probability level for all the plots. The higher correlation coefficient shows that there is a strong association between soil loss and runoff from the plots. The higher the runoff rate more will be the detachment and transportation of soil particles from the soil surface (Fig. 3).

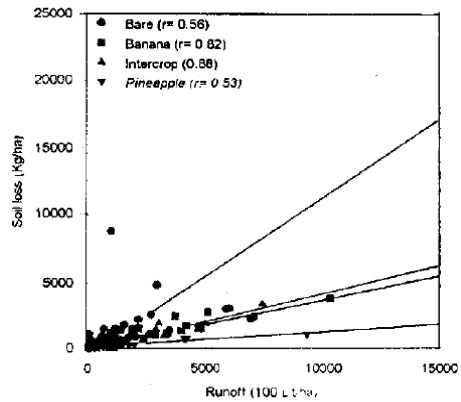

Fig. 3: Relationship of Soil loss and runoff.

This study supports the finding of George (1987) that runoff value decreases; soil loss will progressively decrease. That is only by reducing the runoff from the field was accordingly reduce soil loss to an acceptable level.

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