# Rainfall-runoff-sediment relationship in vegetation fallows in the rainforest zones of southern Nigeria

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**Abstract**

Studies that examined rainfall-runoff-sediment association in fallow vegetation of varying ages are not adequately documented in the literature. The present study evaluated rainfall-runoff and rainfall-sediment association on vegetation fallows; 3-year old, 5-year old and 10-year old in the rainforest zone of southern Nigeria. Measurements of rainfall producing runoff and sediment were carried out from the months of March to November in 2012 rainy season. Sixty-one significant rainstorms were registered, accounting for a total rainfall amount of 1,359 mm. Sixty-one (61) storms of 5.2 mm and above generated measurable runoff on the 5-year old and 3-year old plots, while sixty (60) on the 10-year fallow plot. Out of the sixty-one (61) storms recorded in the entire experiment, fifty-four (54) produced significant sediment on the 5-year fallow plot, forty-four (44) generated sediment on the 3-year fallow plot, while, sediment loss was observed and measured in thirty-six (36) of the rainstorms on the 10-year old fallow plot. Pearson's correlation showed that rainfall had strong, positive and significant relationship with runoff on all the plots. The correlation coefficients in the fallow plots ranged from 0.887 – 0.949and were significant at 0.01 confidence level. The result further revealed that 5.0 to 40.0 mm of rainfall generated the most runoff events experienced on all the plots. Rainfall also had strong, positive and significant relationship with sediment loss. The correlation coefficients in the fallow plots ranged from 0.863 – 0.965 and were significant at 0.01 confidence level. It also showed that 9.0 to 40.0 mm of rainfall yielded the most sediment on all the treatments. Rainfall was observed to have strong relationship with runoff and sediment on all the treatments accounting for a greater variation in erosional losses.

***Keywords:*** *Fallow vegetation, Rainfall, Runoff, Sediment loss*

## Introduction

Rainfall-runoff studies in fallows of different ages give information on vegetation effectiveness in suppressing rainwater which is a potent factor resulting in runoff. It shows the hydrological processes that take place during vegetation regeneration. In fallows, vegetation helps to suppress soil erosion and its associated erosional losses such as runoff (Iwara, 2013). The erosion-suppressing effectiveness of vegetation parameters across different fallow communities depends largely on the age of site abandonment and the type of vegetation. In areas where vegetation is sparse, the amount of runoff could be massive and this may affect the optimum nutrient accretion in the soil due to the loss of topsoil nutrient in liquid form. Soil erosion results in the loss of topsoil which if unchecked could translate into decrease in crop yield for subsequent farming activities or planting seasons (Arwunudiogba, 2000; Wijitkosum, 2012). According to Lal (1989), soil erosion is a serious environmental problem in tropical Africa. This is because it depletes the soil of essential nutrients, making it unsuitable for agricultural production and such a land may not have the productive capacity to support efficient food crop production as a result of the loss in topsoil nutrient.

In areas where climate, soil and topography are similar, differences in soil erosion rates are commonly related to land use or change in land cover (Del Mar Lopez *et al.* 1998). It is therefore imperative to understand the nature of rainfall-runoff association in vegetation fallows to enable better management practices to be put in place to minimize the loss of surface nutrient.In the tropics, the degrading force of soil erosion is caused by rainfall; as such, geomorphologists have used several attributes of rainfall such as rainfall intensity, drop size, duration of fall, annual total amount and frequency of fall, kinetic energy and terminal velocity among others to study soil erosion (Daura, 1995; Eze, 1996; Ezemonye and Emeribe, 2012). Daura (1995) stated that soil erosion results in the removal of soil including plant nutrients from the land surface and its deposition in a different location. The author further argued that soil erosion is more serious on exposed lands than in areas with vegetal cover. Erosional losses are also more serious in fallows with sparse vegetation mostly herbaceous cover than in fallows with the abundance of herbs.

The intensity, frequency and amount of rainfall have intense effects on the volume of surface runoff, sediment and nutrient losses. Lal (1980) and Young (1989) opined that eroded topsoil or sediment contains about three times more nutrients than the soil left behind, because the enriched portion of the soil is loss. Few documented studies are available on rainfall-runoff-sediment relationship in abandoned farmlands of varying ages. However, majority of the available studies examined rainfall-runoff and sediment relationship in different land uses, cropping system and plantations (Daura, 1995; Eze, 1996; Zhao *et al.* 2004; Neergaard*et al.* 2008; López-Tarazón*et al.* 2010; Makanjuola*et al.* 2011; Zhao *et al.* 2014). Others examined the association at different surfaces such as vegetated, mulched and bared surfaces (Abuaand Digha, 2015). Since there is paucity of studies on rainfall-runoff-sediment relationship in abandoned farmlands of varying ages.The present study was therefore conducted to determine the rainfall-runoff-sediment relationship in abandoned farmlands of 10-year old, 5-year old and 3-year old.

## Material and methods

### *Study area*

The study was carried out in Agoi-Ekpo, one of the villages that constitute Yakurr Local Government Area of Cross River State. It is located on 5° 50' 0" North and 8° 16' 0" East (Maplandia.com 2005 cited in Iwara, 2013). The area falls within the lowland of south-eastern Nigeria called the Cross River plain (Ileoje, 2009). Agoi-Ekpo lies within the hot-wet equatorial climate of the tropics and is characterised by high temperature, heavy rainfall and high relative humidity (Iwara, 2013; 2014). Vertisols are the main soils type found in the area. The geology/parent material is of cretaceous sediments (Oden et *al.* 2012 cited in Iwara, 2014). The area has luxuriant forest vegetation and the inhabitants are largely farmers, while teaching and civil service are the paramount white collar jobs (Iwara, 2013).

### *Experimental time period*

There is no generally acceptable time period for soil erosion studies. Studies on runoff and nutrient loss have over the years considered different experimental time periods. The duration chosen may depend on the need of the study and existence of permanent runoff plots among others. The study carried out by Lal and Mishra (2015) assessed runoff and nutrient loss in two (2) months. Daura (1995) studied runoff, soil and nutrient loss in one (1) year. Also, Ramos and Martinez-Casasnovas (2006) used one (1) cropping season or year to examine nutrient losses by runoff in vineyards. A 3 year study of Soil and nutrient losses were carried out by Ali et al., (2007). Mandal et al., (2012) used 5years data to assess erosional losses under different time periods (2005 – 2009). These studies among several others used different time periods to study runoff, sediment and nutrient losses from a watershed. The present study assessed nutrient losses in abandoned farmlands from March 2012 to March 2013. However, analysis is done for 54 rainstorms with eroded sediment.

### *Site sampling*

Fallows of 3-year old, 5-year old and 10-year old were identified and sampled using information on land use history (fallow ages) provided by the local farmers through participatory rural appraisal(PRA). In each identified fallow category, runoff plot of 10m x 4m was constructed; from the runoff plots, surface runoff and sediment loss were obtained.

### *Design and installation of runoff plots*

Runoff plots were constructed using a wooden plank extending 10cm below and protruding for 15cm above the ground. All plots were 10m long and 4m wide giving a total area of 40 sq. meters

(0.004 hectare). At the tail end of each plot, a gutter or channel for runoff collection was constructed at the outlet and storage container (.i.e. a 250-litre container drum) was installed to collect runoff after each rainstorm. The collection container was installed in a pit of 5m by 5m wide and 3.5m deep. The PVC pipe performed the function of conveying the runoff and sediment into the collection container.

***Rainfall, runoff and sediment loss estimation***

Rainfall was measured with a simple rainfall gauge and the amount was measured every morning at 0900 hours using a measuring cylinder. The rain gauge was located 40 m from the runoff plots. Rainfall data were collected March to November 2012. Runoff amount was measured in liters. The runoff and sediment loss amounts were measured following procedures described by Zheng (2005) and Adediji (2006). The sediment was air-dried and weighed in grams using an electronic balance (OHAUS Corporation, Serial No: 7129350674, New York, USA). The units of runoff were converted from liters to millimeters, while sediment loss measured in grams was converted to kilogram per hectare (kg $ha^{-1}$) using the formula given by Vadas, et al. (2002) as follows:

$$\text{Runoff (mm)} = \frac{[\text{Runoff (L)}] \times [1000\ (cm^3\ L^{-1})] \times [10\ (mm\ cm^{-1})]}{\text{Plot area } (cm^2)}$$

Here, the plot area in metres (m) was converted to centimeters (cm) by multiplying the values in meters by 100. Therefore, the length of the plot being 10 m becomes 1000 cm, while the width being 4 m becomes 400 cm. Hence, 1000 cm x 400 cm gives 40000 $cm^2$

This becomes:

$$\text{Runoff (mm)} = \frac{[\text{Runoff (L)}] \times [1000] \times [10]}{400000\ (cm^2)}$$

While sediment loss was calculated thus:

$$\text{Sediment Loss (kg } ha^{-1}) = \frac{[\text{Soil loss (g)}] \times [\text{Runoff (L)}] \times [10^4\ (cm^2\ ha^{-1})]}{1000\ (g\ kg^{-1}) \times \text{Plot Area } (cm^2)}$$

This becomes:

$$\text{Sediment Loss (kg } ha^{-1}) = \frac{\text{Soil loss (g)} \times \text{Runoff (L)} \times 100000000}{1000 \times 400000}$$

***Statistical analytical***

Data on runoff volume and sediment losses was analysed using charts, tables, simple percentages, averages, Pearson’s correlation and one-way analysis of variance. Statistical analysis was carried out using the SPSS software (Version 22; SPSS; Chicago, IL, USA).

## Results

### *Analysis of rainstorm and runoff incidence*

During the experiment, runoff and sediment loss were more on the 5-year old fallow. Thus, sixty-one (61) storms of 5.2 mm and above generated measurable runoff on the 5-year old and 3-year old plots, while sixty (60) on the 10-year fallow plot. On the other hand, out of the sixty-one (61) storms recorded in the entire experiment, only fifty-four (54) storms generated sediment. On the 5-year old fallow, fifty-four (54) of the runoff produced significant sediment, while on the 3-year fallow, surface runoff and associated sediment loss was observed for forty-four (44) of the rainstorms. For the 10-year old fallow, sediment loss was observed and measured in thirty-six (36) of the rainstorms out of the fifty-four (54) rainstorms that generated sediment on the 5-year old fallow.

Runoff and sediment loss vary overtime among the plots as a result of the differences in plot treatment – vegetation establishment and type. Also, much of the variability in soil erosion across the runoff plots may be explained by differences in site characteristics (mostly litter depth, crown and ground cover). The 10-year old fallow plot composed basically of trees with few stands of shrubs and herbs. On the 10-year old plot, there were more of trees. The 5-year old fallow plot was principally made up of shrubs with few stands of trees and herbs; hence, it had more of shrubs. The 3-year old fallow plot was composed solely of herbs with few stands of shrubs. *Chromolaena odorata* dominated the 3-year old runoff plot.

### *Rainfall*

Sixty-one significant rainstorms were registered during the cropping and rainy season of 2012, accounting for a total rainfall amount of 1,359 mm (Table 1). In a related study, Kissa *et al.* (2013) reported similar rainfall amount (1000 – 2000 mm) in a rainforest zone of Uganda. The rainfall amount recorded in this study is below the value of 4,069 mm reported in 2012 for Calabar (Udoimuk *et al.* 2014). Also, Oku *et al.* (2012) observed that in the rainforest zone of Nigeria, annual rainfall far exceeds 3,500 mm. Of the 77 rainfall events recorded, 61 generated runoff. The runoff recording period started in March and ended in November 2012. The high rainfall amount recorded during the duration of the experiment shows a high possibility to produce runoff and sediment loss especially on the fallows with sparse canopy and herbaceous cover (Iwara, 2013).

Table 1: Rainfall (mm) amount across the fallows

| Rainfall | N | Min | Max | Sum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| Rainfall amount | 61 | 5.2 | 101.2 | 1360.0 | 22.30 | 19.18 |

***Runoff and sediment losses across fallow vegetation***

Table 2 gives information on the annual runoff and sediment loss recorded on the various fallow plots. It showed that average runoff volume for the three plots ranged from 0.26 to 0.47 mm with the highest runoff volume recorded on the 5-year fallow plot, while the 10-year fallow plot experienced the lowest. The runoff loss from the 10-year old fallow was negligible with annual runoff value of 6.63 mm. The annual runoff in other plots (treatments) was 15.83 mm, 28.84 mm and 25.30 mm for 5-year old fallow and 3-year old fallow plot respectively. The result simply means that the 5-year-old plot was most effective in runoff (Iwara, 2014). The variation in runoff volume across the fallow ages is attributed to the differences in surface cover mostly vegetation and herbaceous in intercepting and reducing the kinetic force of rainfall. Runoff volume varied significantly among the fallow plots (F = 22.27, $P<0.05$). The runoff volume recorded on all the treatments were below the values reported by Hidayat*et al.* (2012) on shrubs (72.1 mm), maize (66.2 mm) and natural forest (31.1 mm) plots respectively. The runoff values reported were also below the values reported by Lal (1989) in Ilorin, Nigeria. Lal reported values of 44 mm, 11 mm and 61 mm for bush fallow, traditional farming and no-till respectively. The differences in runoff volumes among the studies are attributed to the type of land use employed in the respective studies as well as on the duration of experiment.

The average and total sediment losses for the different fallow plots are also shown in Table 2. It showed that the 5-year-old fallow plot experienced the highest sediment loss with an average value of 209.24kg/ha/year, while the 10-year-old fallow experienced the lowest 12.43kg/ha/year. The differences in sediment loss among the plots were attributed to the variation in the crown cover, and herbaceous cover (density of herbs). The very high sediment loss on the 5-year-old plot is blamed on the existence of canopy gaps with low herbaceous cover percentage. The pattern of sediment loss among the fallow treatments followed a trend similar to that of runoff, with the 5-year old fallow yielding the highest erosional loss. Sediment loss varied significantly among the plots (F = 15.43, $p<0.05$). The amount of sediment loss observed across the treatments is higher than the values reported by Daura (1995), in University of Ibadan, Nigeria, and Avwunudiogba (2000) across different tillage practices in southwestern Nigeria. The differences in rainfall amounts and treatments used may be responsible for the observed variation. Avwunudiogba study lasted for 5 months (March to July, 1994) and soil loss values ranged from 276 to 7,672 kg $ha^{-1}$ for fallow (control) and maize planted on no-tillage respectively. As rightly argued above, differences in rainfall amounts and frequency as well as the duration of study may be attributed to the variation in sediment/soil loss recorded. In this study, 54 rainstorms that generated measurable sediment on all the plots were evaluated, while the study by Avwunudiogba and Daura recorded 23 and 43 rainfall events that generated soil loss respectively. The differences in measured eroded soil may also be attributed to the sizes of runoff plots.

Table 2: Runoff and sediment losses across vegetation fallows

| Erosional losses | Fallows | | | | | | F- value |
|---|---|---|---|---|---|---|---|
| | 3-year | | 5-year | | 10-year | | |
| | Sum | Avg. | Sum | Avg. | Sum | Avg. | |
| Runoff (mm) | 15.83 | 0.26 | 28.84 | 0.47 | 6.63 | 0.11 | 22.27* |
| Sediment loss (kg/ha) | 2729 | 50.54 | 11299.05 | 209.24 | 671.0 | 12.43 | 15.43* |

Significant at 5% alpha level

***Rainfall-runoff association***

Pearson's correlation result on Table 3 showed that rainfall had strong, positive and significant relationship with runoff on all the plots. The correlation coefficients in the fallow plots ranged from 0.887 – 0.949. This implies that runoff volumes across the plots are related to rainfall. This result corroborates those of Daura (1995) and Pimentel and Burgess (2013) that rainfall is the most important climatic parameter controlling runoff and associated losses on agricultural land. According to Lal (1989), rainfall is a global problem, but in tropical Africa, it represents a serious problem resulting in the diminishing of soil fertility. The association between rainfall and runoff on the 10-year fallow plot showed a direct relationship (Fig. 1), as its volume increased with rainfall irrespective of the vegetation. The $R^2$ result indicated that 90.1 per cent of the runoff experienced on the 10-year fallow plot was principally caused by rainfall, while 0.9 per cent of the unexplained variance in runoff volume was attributed to other parameters not necessarily rainfall.

Furthermore, the pattern of associations between rainfall and runoff on the 5-year and 3-year plots equally displayed a direct relationship (Fig. 2 – 3), as runoff volume also increased with rainfall. The $R^2$ result for the respective treatments showed that 84.3 and 78.6 per cent of the runoff experienced on the 5-year fallow and 3-year fallow plots respectively were principally caused by rainfall; and that 15.7 and 21.4 per cents of the unexplained variance in runoff volume on the 5-year fallow and 3-year fallow plots respectively were attributed to other parameters, not necessarily rainfall. In addition, Fig. 1–3 revealed that 5.0 to 40.0 mm of rainfall generated the most runoff events experienced on all the plots.

Table 3: Zero-order correlation matrix between rainfall (mm) and runoff (mm)

| Variables | Rainfall | 10-year fallow | 5-year fallow | 3-year fallow |
|---|---|---|---|---|
| Rainfall | 1 | | | |
| 10-year fallow | 0.949* | 1 | | |
| 5-year fallow | 0.918* | 0.942* | 1 | |
| 3-year fallow | 0.887* | 0.903* | 0.934* | 1 |

*Correlation is significant at the 0.01 level (2 – tailed)

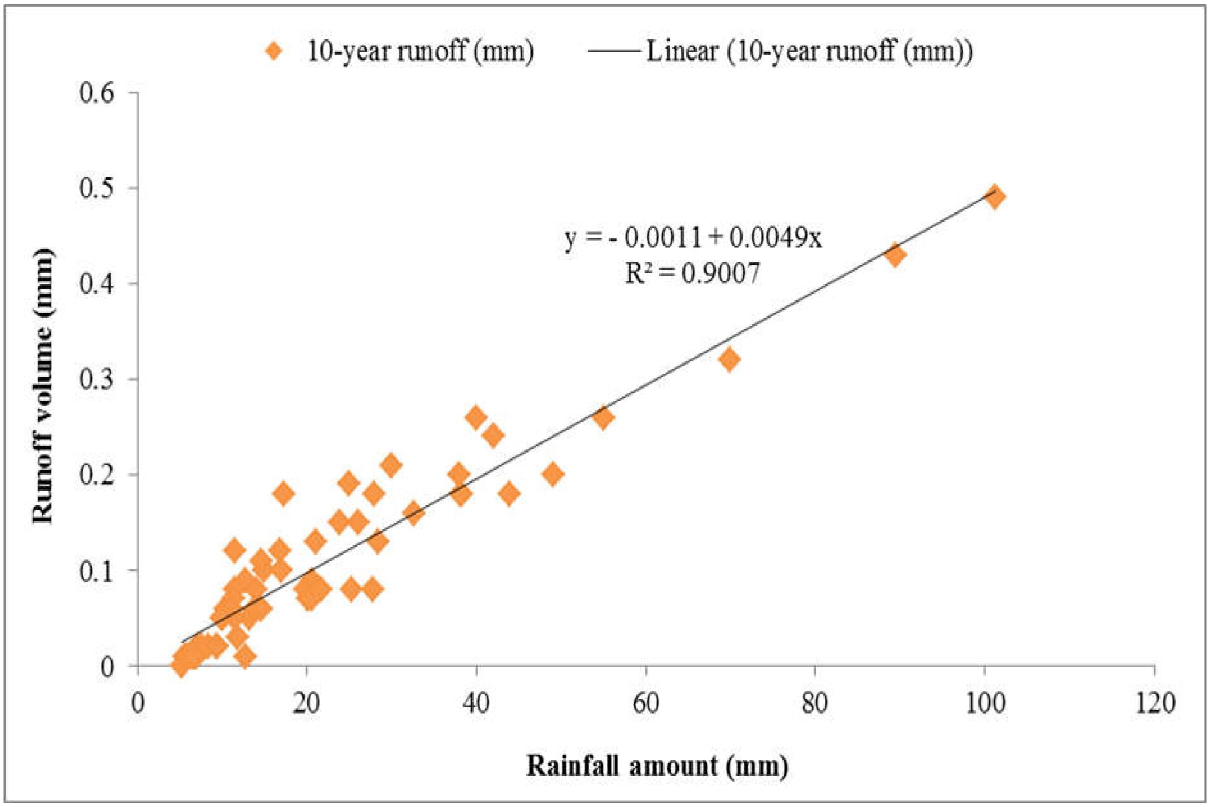


Fig 1: Rainfall - runoff relationship on the 10-year fallow

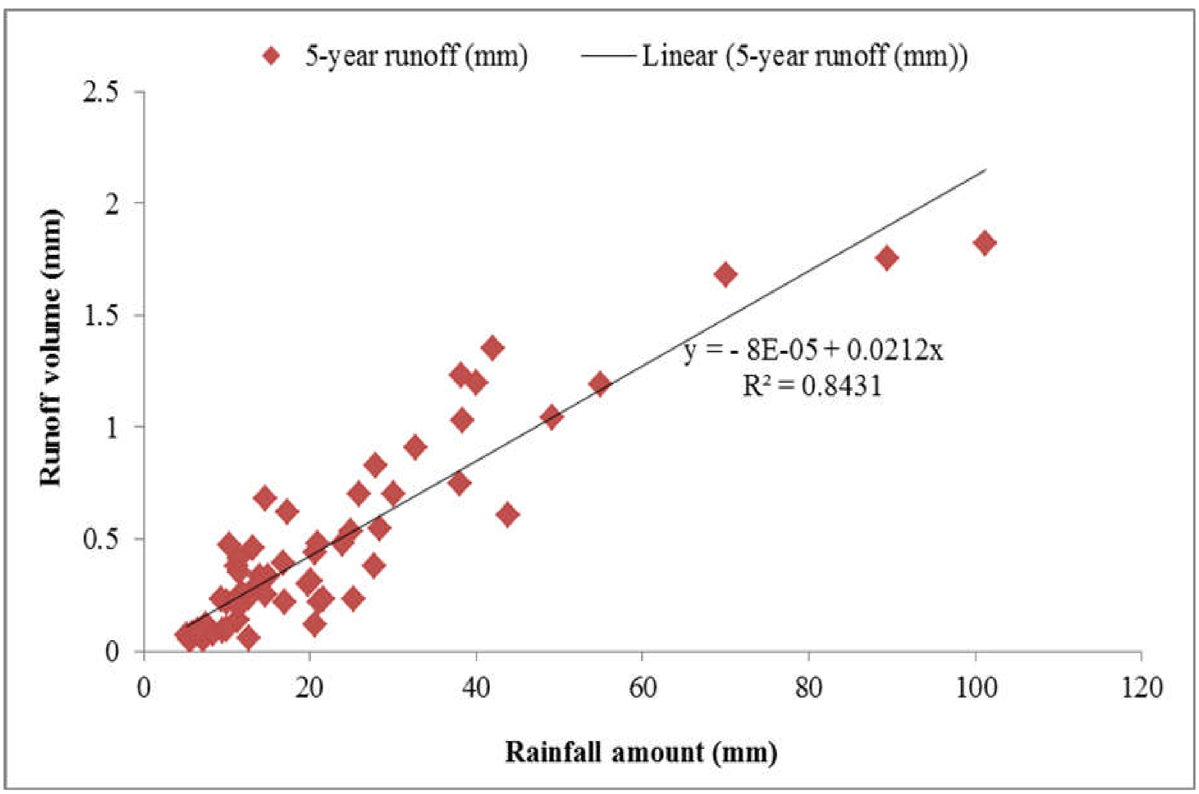


Fig 2: Rainfall - runoff relationship on the 5-year fallow

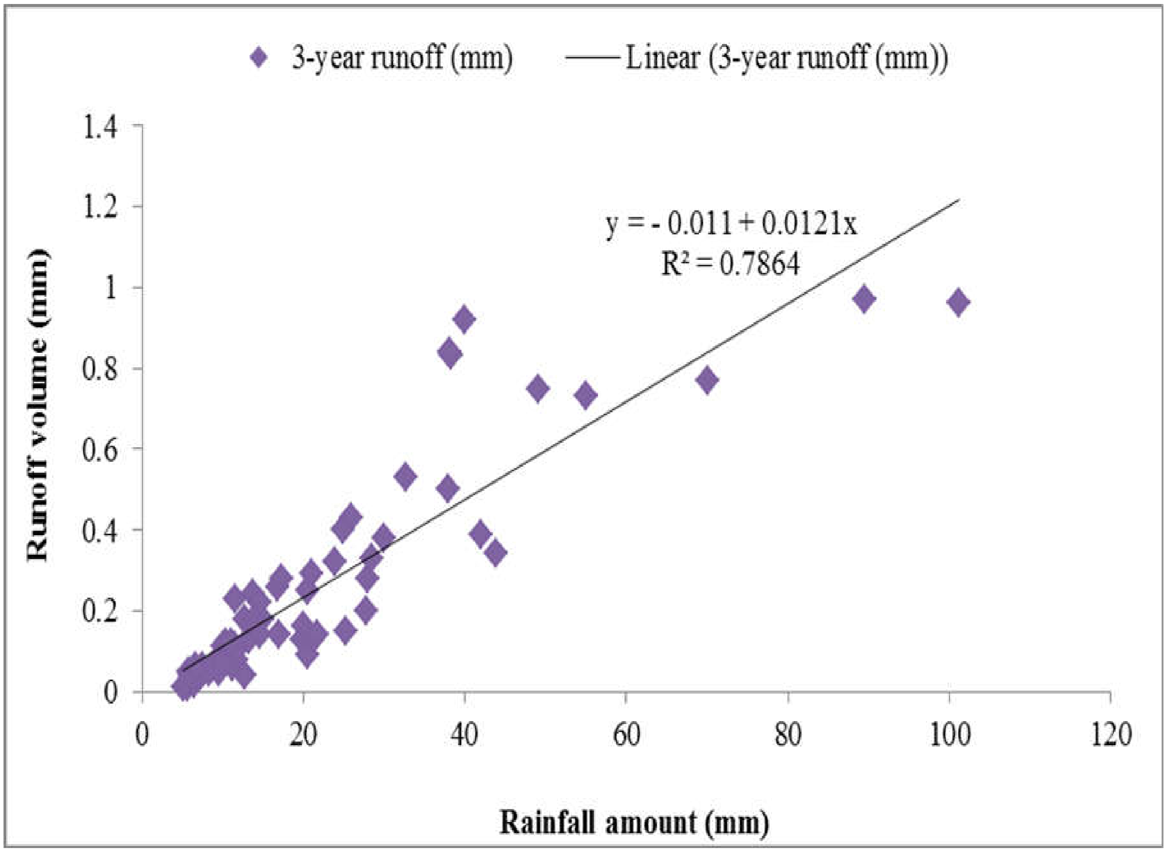


Fig 3: Rainfall - runoff relationship on the 3-year fallow

***Rainfall-sediment association***

The association between rainfall and sediment loss followed the same pattern with those of runoff on all the plots. The result of Pearson's correlation in Table 4 indicated that rainfall had strong, positive and significant relationship with sediment loss. The correlation coefficients in the fallow plots ranged from 0.863 – 0.965 and were significant at 0.01 confidence level. This also indicated that sediment generation on the fallow plots was directly related to rainfall amount. Increase in rainfall amount and frequency resulted in the increase in sediment loss. Similar result was reported by Egharevba and Ibrahim (2006) when they observed a linear relation between rainfall and sediment loss from agricultural land in the southern guinea savanna zone of Nigeria. Also, Sharma (1996) studied soil erosion and sediment yield in the Indian arid zone and noted that sediment yield increases with increasing rainfall. The association between rainfall and sediment loss on the 10-year fallow plot indicated a direct relationship (Fig. 4), which implied that sediment yield increased with the increased in rainfall irrespective of the vegetation. The $R^2$ result on the 10-year fallow plot showed that 74.5 per cent of the sediment yielded was caused by rainfall, while 25.5 per cent of the unexplained variance in sediment yield was attributed to other factors. The pattern of relations between rainfall and sediment yield on the 5-year fallow and 3- plots likewise showed a direct association (Fig. 5 – 6). This is because the amount of sediment loss increases with rainfall. The $R^2$ result for the respective treatments shows that 82.2 and 85.5 per cent of the amount of sediment loss experienced on the 5-year fallow and 3-year fallow plots respectively were principally caused by rainfall; and that 17.8, 14.5 and 16.5 per cent of the unexplained variance in sediment yield on the 5-year fallow and 3-year fallow respectively were attributed to other parameters not necessarily rainfall. In addition, the figures (Fig. 4 – 6) indicated just like runoff that 9.0 to 40.0 mm of rainfall yielded the most sediment on all the treatments. The rainfall amounts recorded in the present study are high compared to the values reported by Daura (1995) in Ibadan, south-western Nigeria. The high rainfall amount recorded for the experiment is evident of the rainforest zone, where the experiment was carried out. The values were however within those reported by Egbai *et al.* (2012) carried out in Cross River State.

Table 4: Correlation matrix rainfall and sediment loss (kg ha-1)

| Variables | Rainfall | 10-year fallow | 5-year fallow | 3-year fallow |
|---|---|---|---|---|
| Rainfall | 1 | | | |
| 10-year fallow | 0.863* | 1 | | |
| 5-year fallow | 0.906* | 0.952* | 1 | |
| 3-year fallow | 0.925* | 0.955* | 0.965* | 1 |

*Correlation is significant at the 0.01 level (2 – tailed)

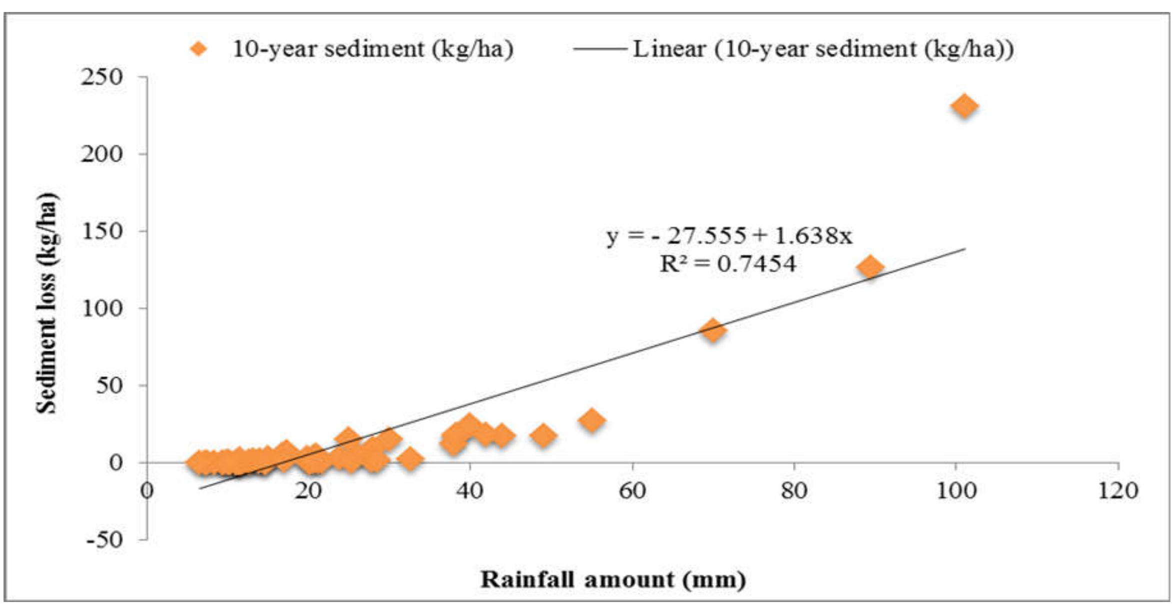


Fig: 4: Rainfall - sediment relationship on the 10-year fallow

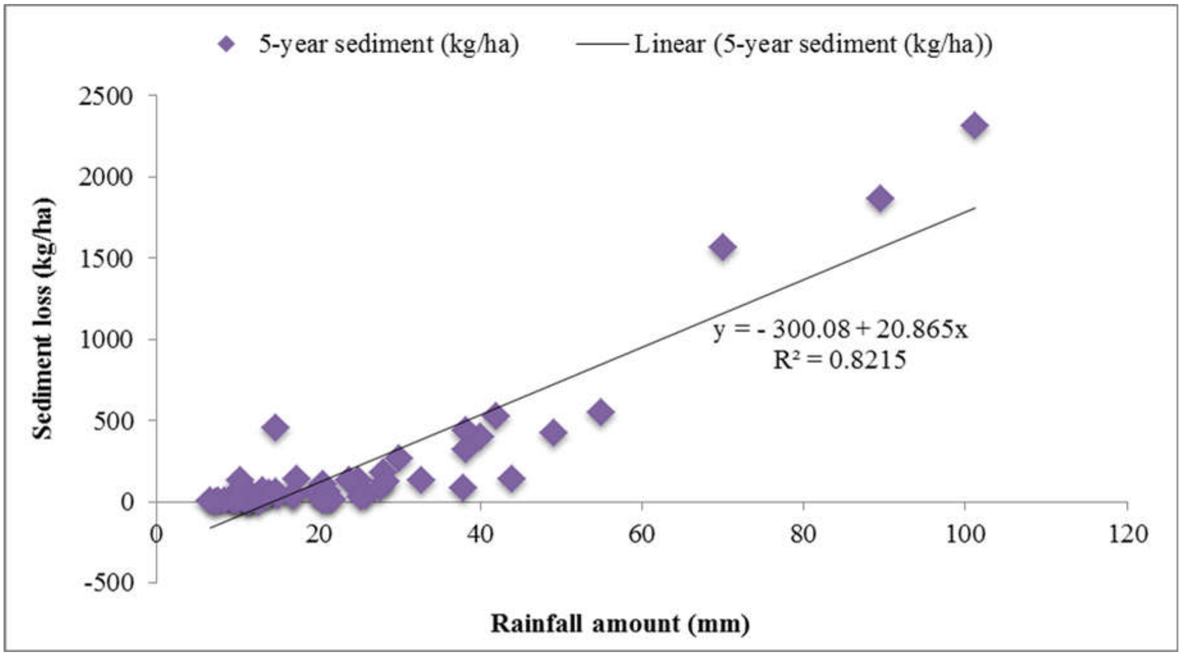


Fig: 5: Rainfall - sediment relationship on the 5-year fallow

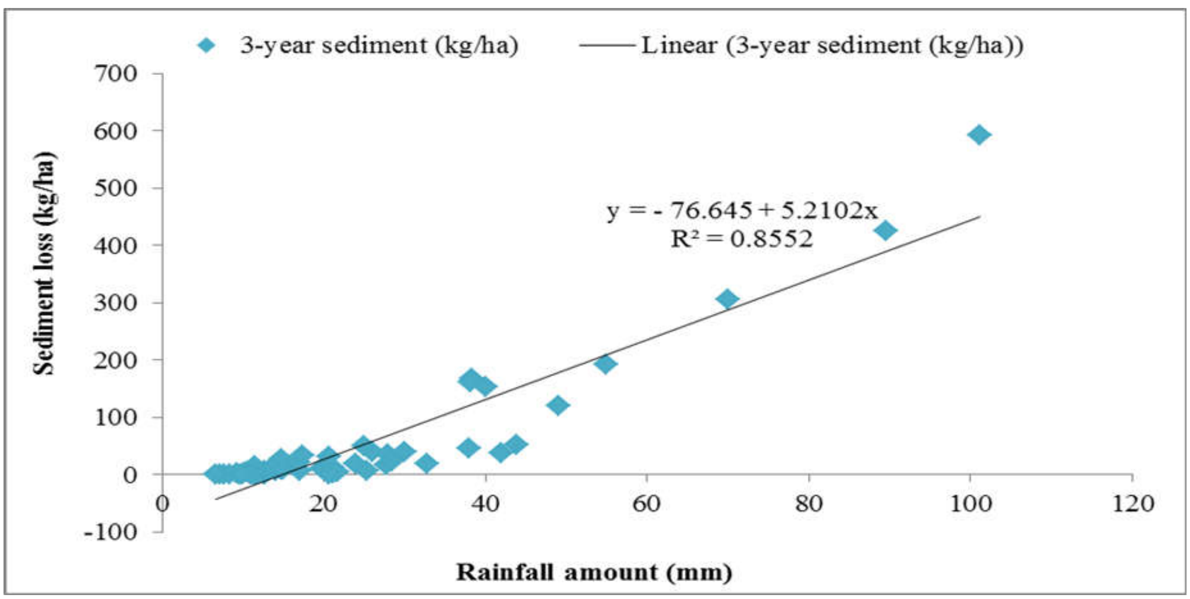


Fig 6: Rainfall - sediment relationship on the 3-year fallow

**Discussion**

The rainfall-runoff-sediment analysis has shown that runoff volume and sediment loss on all the plots increase with rainfall amount and frequency. This conforms to the assertions of Lu *et al.*(2007) and Jiao *et al.* (2009) that the amount, frequency and intensity of rains exert profound effects on the volume of surface runoff, soil and nutrient losses. More so, the analysis indicates that runoff and sediment loss are effectively reduced on the 10yr-old fallow as vegetation components help to delay instantaneous runoff and therefore encourage infiltration. Also, the low sediment loss recorded on the 10yr-old fallow plot may be as a result of the reduction in run-off and the enhancement of infiltration due to the high litter depth found on the topsoil; which helps to improve the soil structure. These results are in agreement with the findings of Almas and Jamal (1999) and Siriri*et al.* (2006) when they demonstrated that the maintenance of adequate surface cover may serve to conserve soil by reducing runoff velocity vis-à-vis sediment loss. Sediment loss on the 5-year, 3-year and cultivated farmland plots are observed to increase with runoff depth. Egharevba (2004) noted that sediment yield increased with runoff depth.

Runoff volume has been noted to be an important factor in determining sediment and nutrient losses (Yang *et al.* 2009). The loss of topsoil could translate into decrease in crop yield for subsequent farming (Avwunudiogba, 2000). Thus, the direct impact of raindrops that generates runoff resulting in sediment loss may be minimized with the existence of dense vegetation as noticed on the 10-year old fallow.The low runoff volume experienced on the 10-year old and 3-year old plots is attributed to the rainfall energy interception by the dense vegetation cover and herbaceous (density of herbs) in the respective plots, thus increasing water infiltration and storage and a general maintenance of good soil structure. This implies that increase in surface cover effectively reduces runoff (Ali *et al.* 2007). This assertion is consistent with those of Lal (1995) that crown cover alone does not afford the soil adequate protection against the degrading force of rainwater. Crown cover as noted by Lal (1995) cannot be compared to density of herbs (groundcover). Lal argued that groundcover is more effective in erosion control than tall canopies (crown cover) as a result of its effectiveness to break raindrop impact, traps transported soil particles and dissipates the energy of raindrop.

The high runoff volume and sediment loss recorded on the 5-year old fallow implies that vegetation cover alone does not afford the soil adequate cover, but the availability of ground cover potentials (density of herbs). The ground cover on the 5-year old fallow was scanty. The scanty ground cover was attributed to its previous land use history of unintended bush fire resulting in the burning of undergrowth. This had profound impact on the rapid establishment and growth of ground cover because the rate was rather slow. This is consistent with the finding of Wilson (2005) that fire either unintended or prescribed burning have profound impacts on establishment rates by breaking seed dormancy and altering micro-environmental conditions for germination and growth. The rapid growth in herbaceous species and subsequent herbaceous cover on the cultivated farmland and 3-year old fallow following the rains affords the soil adequate cover to minimize erosional losses. According to Daura (1995), ground cover (undergrowth), plant residues and vegetation cover increases the porosity of the upper horizon of the soil and hence its infiltration capacity.

The study shows that rainfall is the determinant of surface runoff on all the plots. This is because little storm resulted in runoff, and most times with very little sediment generated. For instance, with 5.2 mm of rainfall, runoff of 0.04mm and negligible quantity of soil was eroded on the 5-year fallow plots. The wetness of the soil by previous storms is therefore responsible for the runoff experienced on all the plots. This is so as wet soil is observed to have lower infiltration rates since the pore spaces are already filled with water. This pattern of runoff is also reported in a related study by Makanjuola et al., (2011) that most runoff and soil loss events take place at the periods of high rainfall when soil is very moist.

## Conclusion

The study shows that rainfall has strong relationships with runoff and sediment on all the treatments accounting for a greater variation in erosional losses. This implies that soil erosion and its associated losses on all the treatments are related to rainfall. Increase in rainfall amount and frequency results in erosional losses. Rainfall is therefore identified as the initiator of runoff and its associated losses. This is obvious as material delivery (sediment loss) cannot happen without runoff, as runoff triggers sediment loss. Hence, runoff is the sole cause of sediment loss resulting in the loss of essential topsoil nutrients. It also reveals that soil erosion takes place in vegetation fallows even under substantial vegetal cover, but fallows with greater canopy and herbaceous cover conditions have considerably reduced runoff and sediment loss compared to the fallow area with sparse vegetation attributes.

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