Seasonal Variability in Runoff, Sediment and Nutrient Losses in Vegetation Fallows in The Rainforest Zone of Southern Nigeria

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Abstract

The study assessed seasonal trend in erosional losses on natural fallow vegetation of varying ages in a part of the rainforest zone of Nigeria. Measurements of runoff, sediment and nutrient losses, basically organic carbon (OC) and total nitrogen (TN) were made for the months of March to November in 2012 rainy season using runoff plots of 40 m^2. The highest erosional losses across the plots were observed during months of heavy storms, precisely July, August and September. The 5yr-old plot experienced the highest loss of nutrient (OC: 52.2%, TN: 52.9%), followed by the cultivated farmland (OC: 31.8%, TN: 31.2%), while the 10yr-old and 3yr-old fallows experienced the lowest losses of 3.5%, 3.3% and 12.5%, 12.6% in OC and TN respectively. Monthly volume and quantities of sediment varied significantly among the treatments ($p < 0.05$). The study recommends early cessation of weeding during the commencement of the dry season because it strips the soil of some protective cover for subsequent season.

Keywords: Soil erosion, Monthly erosional losses, Fallows

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Introduction

Rainfall is a seasonal event and its timing enables appropriate planning to be carried out. Rainfall affects planning because its relative amount, seasonal timing, and intensity affect human activities at different spatial and time scales. In order to deal with the management of soil erosion, in terms of its intensity on farmlands, it is important to focus on its seasonal and annual totals and their reliability (Nwoke and Nwaogazie, 2013). In Africa and Nigeria in particular, rainfall peaks usually occur in the months of July to September (Olaniran, 1988; Okonkwo and Mbajiorgu, 2010). These months have days with wetter than normal rainfalls (Nigeria Meteorological Agency, 2010), with implications on the environment; as some environmental hazards are usually experienced during those months. In areas with scanty vegetation, large quantity of soil and nutrients could be lost during these months, thereby making the soil infertile for food crop production (Ezemonye and Emeribe, 2012). In the tropics, rainfall is the main factor driving soil degradation (Lal, 2001). Therefore, identifying months with high erosional losses would enable farmers and land planners to employ measures to reduce the inherent effect.

Diodato and Bellocchi (2010) observed that identifying rainfall scenarios is important for understanding the rainfall and storms characteristics and their potential impact on local agricultural and ecological systems. Thus, understanding the monthly process of soil erosion in successive farmlands enables the monthly rate of sediment loss to be ascertained which would call for appropriate land management measures to minimize the rate of topsoil loss. Studies on the spatial and temporal variability and trend in soil erosion and sediment loss in successional fallow vegetation are not adequately documented in the literature, suggesting that not much research has been done. Majority of the studies in the literature on secondary succession, mainly focused on nutrient returned to the soil (Aweto, 1981a; Diekmann et al. 2007; Aguilera et al. 2013) as well as changes in vegetation characteristics (Aweto, 1981b: Stromgaard, 1986; Feng et al. 2007) in relation to succession time, but studies on nutrient depletion during the period of natural nutrient restoration in fallows of varying ages are not readily available in the literature. Other available studies on soil erosion and sediment loss were carried out on different cropping systems and plantations (Lal 1983; Neergaard et al. 2008; Haridjaja, 2012). Soil erosion studies in fallow vegetation of different ages enable sustainable land management practices to be put in place in order to improve the soil potential for improved agricultural production. In this study, the seasonal variation in soil erosional losses across different fallow ages is examined.

Literature Review

Soil Erosion Processes

Globally, geologic and accelerated erosion are the two main types of erosion causing large-scale land degradation. Geologic erosion is gradual and occurs over a long time. Thus, it involves the normal process of weathering that generally occurs at low rates in all soils as part of the natural soil-forming processes (Blanco and Lal, 2008). These low rates of erosion are essential to the formation of soil. In contrast, accelerated erosion is more devastating and rapid and a major concern because its rate of erosion exceeds a certain threshold level. This type of erosion is usually activated by anthropogenic causes such as deforestation, slash-and burn agriculture, intensive ploughing, intensive and uncontrolled grazing, and biomass burning (Blanco and Lal, 2008). Soil erosion is thus, a complex process that depends on climatic, relief and biological factors. Climatic factors associated with soil erosion are average temperature, storm frequency, amount and intensity of precipitation and seasonality among others. The geologic factors are relief (slope) of the land, soil type and porosity and permeability among others. The biological factors are vegetation and herbaceous cover, land use and the type of organisms inhabiting the area (Montgomery, 2007).

Soil erosion occurs on all land and the agents include water and wind, each contributing a noteworthy amount of sediment loss. The loss of soil from farmland may reduce soil nutrients for crop production as well as affect surface water quality. Changes in land use are generally able to accelerate soil erosion (Williams, 2003), and it has long been acknowledged that erosion in excess of soil production would in the end result in decreased agricultural potential (Williams, 2003). Soil erosion by water is the most degradation type of soil erosion (Blanco and Lal, 2008) due to its geographic spread (Lal, 1989). Soil erosion has an extensive effect mostly on land which is an essential resource for food crop production. In tropical Africa, it constitutes a serious problem (Lal, 1989). According to Jiao et al., (2009) and Ezemonye and Emeribe (2012), the degrading effects of soil erosion depends on several factors which include vegetation, rainfall, topography, soil type and farm management. In the tropics, the erosive force of soil erosion is basically caused by rainfall; the effects of rainfall have made geomorphologists to make use of several attributes of rainfall like annual rainfall amount and frequency, rainfall intensity, drop size and duration of fall among others to understand soil erosion (Daura, 1995; Ezemonye and Emeribe, 2012). In the past two centuries, changes in land uses mostly in connection to anthropogenic activities have accelerated the rates of soil erosion and nutrient loss (Canton et al., 2011). Indeed, human impacts continue to trigger soil erosion and have led to severe land degradation; this has made land unproductive for crop production. The accelerated rates of soil erosion over time due to the continual loss in vegetal cover has led to soil/sediment and nutrient loss, decline in soil organic matter and devastating floods (Canton et al., 2011).

Soil Erosion Dynamics in Fallows

Studies on soil erosion in fallow vegetation of different ages provide an understanding on how erosion occurs resulting in the loss of topsoil nutrients. The loss deprives the soil of essential nutrients being restored during the process of natural nutrients restoration (Iwara, 2013). Such study enables sustainable land management practices to be put in place during the process of natural nutrients restoration, in order to improve the soil potential for improved agricultural production (Iwara, 2014). Ries and Langer (2001) investigated the conditions of runoff generation and soil erodibility in abandoned fields in the Central Ebro Basin, Spain. The study showed that material delivery (sediment yield caused by erosion) did not significantly decrease with increasing vegetation cover, only however, with vegetation cover of over 60% did material output decrease significantly. Zhenhong (2004) and Zhenhong et al., (2006) examined the relationship between plant species diversity and soil erosion on different secondary succession phases of a semi-humid evergreen broad-leave forest in China. The study revealed that plant diversity improved the canopy hydrological effect of plant communities and that plant diversity acted on surface runoff and soil erosion control as well as reduced the risk of phosphorus loss in runoff. The result showed that surface runoff volume of plots decreased with plant species layer and also that soil erosion decreased obviously with increase in species and the relationship showed a negative exponential function between soil erosion and plant species diversity.

Gafur et al., (2000) investigated the impact of burning and subsequent runoff on changes in topsoil nutrients following land clearing and burning the Chittagong hill tracts of Bangladesh. The study reported that runoff removed up to 27% of the nutrient content in the upper 10 cm of soil. That the losses of available Cu and P by erosion are especially important as the contents of the nutrients were very low before burning and were even reduced by the burning. Li et al., (2006) asserted that ground cover is functional in reducing nutrient loss, including C and N, with variation according to disturbance level and successional change. According to Daura

(1995), surface cover which may be ground cover (undergrowth), plant residues and vegetation cover increases the porosity of the upper horizon of the soil hence its infiltration capacity. Vegetation components help to delay instantaneous runoff and therefore encouraged infiltration. Siriri et al., (2006) demonstrated that the maintenance of adequate surface cover may serve to conserve soil by reducing runoff velocity. Vásquez-Méndez et al. (2010) evaluated soil erosion and runoff in different vegetation patches from semiarid Central Mexico. The study reported that soil erosion was different for the studied vegetation patches, thus decreasing as canopy and ground cover increased. The result revealed that runoff was reduced by 87%, 87% and 98% and soil loss by 97%, 93%, and 99% for Acacia farnesiana, Prosopis laevigata and Opuntia spp, respectively, as compared to the control; and that soil surface physical conditions were different between the low vegetation cover conditions and the greater vegetation cover conditions, indicating a positive effect of vegetation patches on the regulation of surface hydrological processes.

Material and Methods

Study Area

The study was carried out in Agoi-Ekpo, one of the villages in Yakurr Local Government Area of Cross River State. Its geographical coordinates are 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) while the topography of the study sites is near level (3 degrees). The area has luxuriant forest vegetation. The inhabitants are mostly farmers, while teaching and civil service are the paramount white-collar jobs (Iwara, 2013; 2014).

Site Sampling

Fallows of 3yr-old, 5yr-old and 10yr-old and a cultivated farmland were identified and sampled using information on land use history (fallow ages) provided by the local farmers. In each identified fallow category, runoff plot of 10m x 4m was constructed; from this runoff plot, surface runoff and sediment loss were obtained. All runoff plots were in the same site, similar topography, climate and soil types.

Design and Installation of Runoff Plots

In each fallow category, runoff plot was constructed on an area of slopes not exceeding 3^0 (i.e. 3 degrees). Four 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 in the rainy season period of 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 air-dried sediment samples were taken to the laboratory for analysis of organic carbon and total nitrogen using standard methods. The units of runoff were converted from liters to millimeters following the formula given by Vadas et al., (2002) as follows:

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

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 10m becomes 1000 cm, while the width being 4m becomes 400 cm. Hence, 1000cm x 400cm gives 40000cm^2. This becomes:

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

The sediment loss measured in grams was then converted to kilogram per hectare (kg ha-^{1}) using the formula given by Vadas et al., [2002] as:

$$\text{Sediment Loss (kg ha}^{-1}) = \frac{[\text{Soil loss (g)}] \times [\text{Runoff (L)}] \times [100^4\ (\text{cm}^2\ \text{ha}^{-1})]}{1000\ (\text{g kg}^{-1}) \times \text{Plot Area (cm}^2)}$$

This becomes:

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

In addition, nutrient loss in kilogramme per hectare (kg ha^{-1}) was estimated following the formula given by (Ali et al., (2007); and Munodawafa (2012). For organic carbon and total nitrogen with losses measured in %:

$$\text{Nutrient Loss (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%) x Sediment loss (kg ha}^{-1}\text{)}}{100}$$

Analytical Technique

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

Results

Monthly Runoff on the Plot Treatments

The monthly volume of runoff generated across the fallow treatments is depicted in Table 1 and Figure 1. Rainfall amount increased from 12.7 mm in March to a maximum value of 281.9 mm in September and then dropped to 10.0 mm in November signaling the commencement of the dry season. The months of July, August and September recorded the highest rainfall, with a total greater than 200.0 mm (Table 1). The month of July had the most number of rainstorms amounting to 273.9 mm, followed by September, August and October with rainfall total of 281.9 mm, 246.2 mm and 124.3 mm respectively; while March and November had the least frequency of rainfall with single storms of 12.7 mm and 10.0 mm respectively. The month of July recorded the highest runoff across the plots; this was closely followed by the months of September (for 10yr-old, 5yr-old and 3yr-old plots) and May (for farmland). Runoff volume varied across the fallow plots in the months of April, May, July and October (Table 1). Runoff volume on all the plots increased with rainfall frequency (Figure 1). This trend is consistent with the observations of earlier and related studies, like those of Ali et al., (2007) where runoff volume linearly increased with rainfall amount. There was a significant variation in the monthly runoff amount among the treatments ($F = 3.419$, $p < 0.05$).

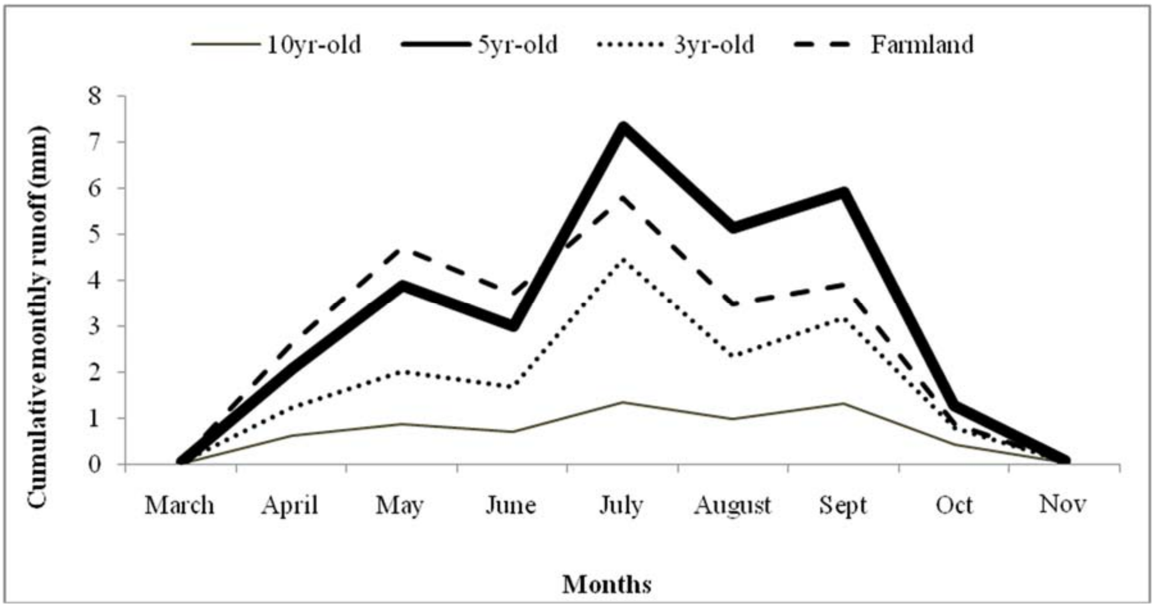

Fig 1: Trend in runoff (mm) frequency
Source: Researcher's fieldwork, 2012

Table 1 Cumulative monthly and frequency of rainfall (mm) and runoff (mm)

Months	No. of storms	Rainfall amount	10yr-old	5yr-old	3yr-old	Farmland	F-values
March	1	12.7	0.01	0.06	0.04	0.07	0
April	7	125.6	0.64	2.1	1.24	2.63	5.663*
May	7	156.0	0.88	3.90	2.00	4.72	10.532*
June	6	128.4	0.72	3.00	1.69	3.72	2.873 ns
July	12	273.9	1.36	7.34	4.46	5.80	4.965*
August	9	246.2	1.00	5.15	2.35	3.50	1.898 ns
September	10	281.9	1.32	5.92	3.19	3.91	1.974 ns
October	8	124.3	0.42	1.27	0.79	0.87	6.256*
November	1	10.0	0.05	0.10	0.07	0.08	0
Total	61	1,359	6.63	28.84	15.83	25.30	

*Monthly variation in runoff is significant at 1% confidence level
ns = Monthly variation in runoff is insignificant at 5% confidence level
Source: Researcher's fieldwork, 2012

Monthly Sediment Loss on all the Plots

The monthly amount of eroded soil on all the treatments is depicted in Table 2. The pattern of sediment loss followed the same trend with runoff, as the amount of eroded sediment happens to increase with the frequency and total amount of rainfall (Ali et al. 2007). The maximum monthly sediment loss on the 5yr-old and 3yr-old plots occurred in September with values of 3752.16 kg ha^{-1} and 784.60 kg ha^{-1}; while on the 10yr-old and farmland plots, the maximum sediment loss occurred in August with total loss value of 255 kg ha^{-1} and 1510.39 kg ha^{-1} respectively (Table 2). Sediment loss on the 5yr-old, 3yr-old plot and farmland was observed to increase with runoff depth. The months of July, August and September yielded more amounts of sediment across the plots. This is expected as these months are usually associated with heavy rainstorms and more frequent rainfall events. As usual, sediment loss increased with rainfall frequency. This is evident as earlier scholars have identified the amount, frequency and intensity of rains to exert profound effects on the volume of surface runoff, soil and nutrient losses (Jiao et al. 2009). Monthly sediment loss across the plot treatments varied significantly ($F = 3.576$, $p < 0.05$).

Table 2 Cumulative monthly and frequency of rainfall (mm) and sediment loss (kg ha^{-1})

Months	No of storms	Rainfall amount	10yr-old	5yr-old	3yr-old	Farmland	F-values
March	1	12.7	0	0.28	0	0.49	0
April	7	125.6	27.62	315.87	102.56	374	2.489 ns
May	7	156.0	41.30	565.39	183.76	968.61	5.794*
June	5	125.1	44	933.45	259	948.77	1.939 ns
July	11	267.4	83	2471.15	694	1448.97	6.792*
August	7	236.3	255	3195.49	693.12	1510.39	1.042 ns
September	7	264.4	218.81	3752.16	784.60	1458.70	1.753 ns
October	8	124.3	1.46	64.28	12.69	22.67	3.442^{+}
November	1	10.0	0	0.98	0.07	0.31	0
Total	54	1,322	671.19	11299.05	2729.80	6732.91	

*Monthly variation in sediment loss is significant at 1% confidence level

$^{+}$Monthly variation in sediment loss is significant at 5% confidence level

ns = Monthly variation in sediment loss is insignificant at 5% confidence level
Source: Researcher's fieldwork, 2012

Monthly OC and TN Loss on the Treatments

Table 3 and Figures 2a – 2b show the amount of nutrients that eroded from the soil. The month of March experienced a single rainfall of 12.7 mm that resulted in 0.01 kg ha^{-1} loss of organic carbon (OC) on the 5yr-old. In this month, very low quantities of nutrients were lost from the soil because it was the first rain of the experiment. In April, there was a significant increase in the quantities of nutrients that eroded the cultivated farmland and fallow soils as the eroded soils were enriched with nutrient. The month of July displayed a distinct pattern in nutrient losses in the respective plots, as high nutrient losses were experienced on the 5yr-old fallow plot, followed by the cultivated farmland (Table 3). The reason for this was attributed to the rapid growth in herbaceous species and sprouting of cassava leaves. The rapid growth of herbaceous species (ground cover) provided cover to the soil which reduced the quantities of nutrients that eroded the cultivated farmland plot. The month of July experienced the highest frequency of rainfall events (11) and highest rainfall amount (267.4 mm). The loss in OC and total nitrogen (TN) on the 5yr-old and cultivated farmland plots showed a considerable increase. The losses in these nutrients far exceeded the values recorded in April, May and June. This implies that nutrient loss from the soil increases with the rains. This is consistent with the findings of Makanjuola et al. (2011) who also recorded increase in nutrient loss with increase in rainfall amount. The high erosional losses on the 5yr-old plot in comparison to the 3yr-old plot was unexpected. It is however attributed to the existence of scanty undergrowth and existence of canopy gaps. The scanty undergrowth (herbaceous species) noticed on the 5yr-old fallow is blamed on its previous land use history of unintended bush burning resulting in the death of undergrowth. This had profound impact on the rapid establishment and growth of herbaceous species which was rather slow throughout the duration of the study. This is consistent with the finding of Maret and 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 3yr-old fallow following the rains afforded the soil adequate cover to minimize erosional losses.

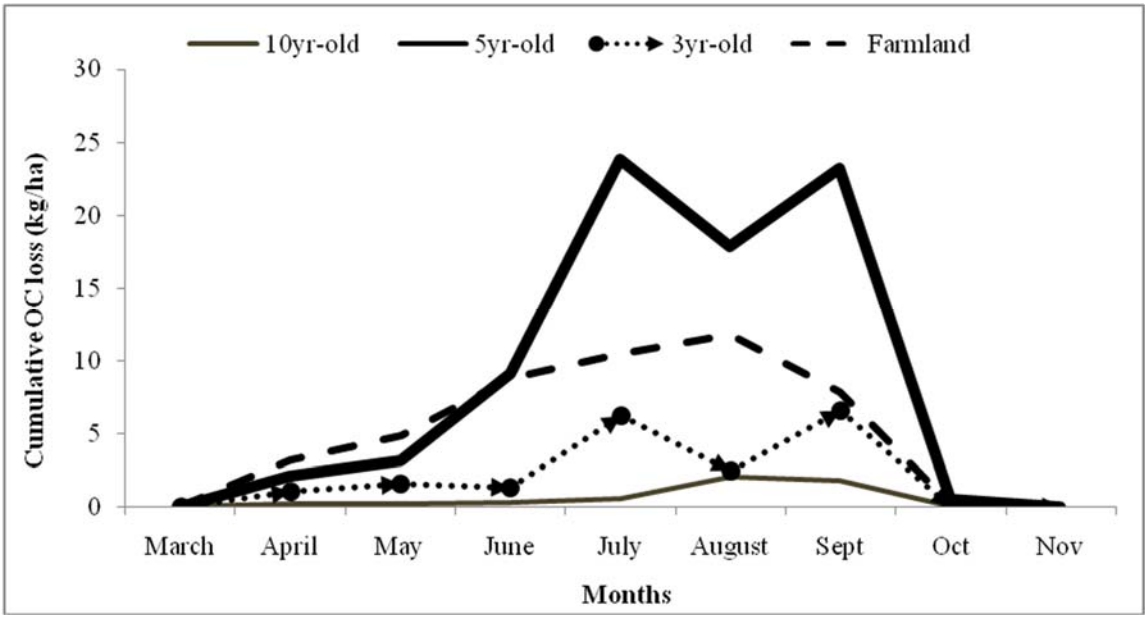

Fig 2a: Trend in OC loss (kg/ha)
Source: Researcher’s fieldwork, 2012

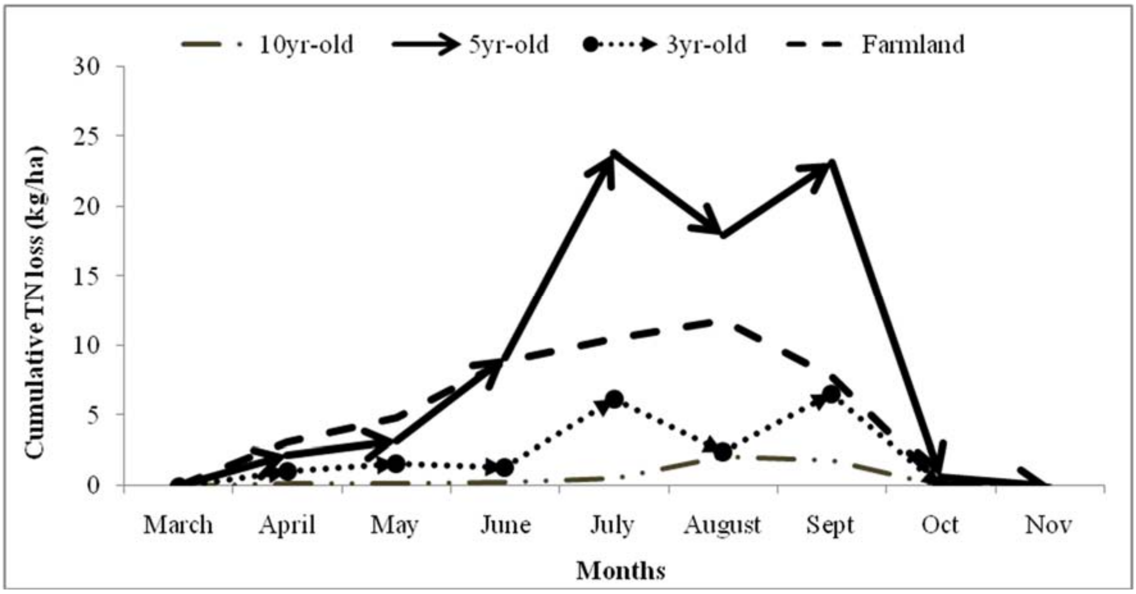

Fig 2b: Trend in TN loss (kg/ha)
Source: Researcher's fieldwork, 2012

Similar trend in OC and TN loss was observed for the other months. In November, a single rainstorm with measurable runoff and eroded sediment was recorded. Though there were sporadic rainstorms in the month, the rainstorms did not generate runoff across the plots as the amounts were >5 mm. The only rainfall event of 10.0 mm caused nutrient losses on the 5yr-old fallow and cultivated farmland plots. The monthly nutrient loss indicated that September (8.91 kg ha^{-1}), July (98.77 kg ha^{-1}), September (27.24 kg ha^{-1}) and August (48.66 kg ha^{-1}) experienced the highest OC losses on the 10yr-old fallow, 5yr-old fallow, 3yr-old fallow and cultivated farmland plots respectively. In addition, the quantities of TN loss varied across the months and plots. The analysis showed that August (2.05 kg ha^{-1}), July (23.81 kg ha^{-1}) and September (6.58 kg ha^{-1}) recorded the highest TN losses on the 10yr-old, 5yr-old and 3yr-old fallow plots respectively, while on the cultivated farmland, August received the highest TN loss of 11.80 kg ha^{-1} (Table 3). The result showed increase in the quantities of OC and TN that eroded the soil; it implied that the frequency of rainfall intensity and amount of rainfall cause substantial loss in soil nutrients.

Table 3: Cumulative monthly and frequency of OC and TN loss (kg ha^{-1})

Months	No of storms	10yr-old		5yr-old		3yr-old		Farmland	
		OC	TN	OC	TN	OC	TN	OC	TN
March	1	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
April	7	0.72	0.16	8.83	2.14	4.15	1.01	12.86	3.13
May	7	0.66	0.15	13.19	3.18	5.91	1.55	14.50	4.82
June	5	1.33	0.31	37.72	9.09	5.38	1.29	36.67	8.83
July	11	2.07	0.51	98.77	23.81	26.63	6.20	43.38	10.51
August	7	8.37	2.05	73.28	17.89	9.85	2.38	48.66	11.80
September	7	8.91	1.78	96.20	23.18	27.24	6.58	44.76	7.81
October	8	0.03	0.00	2.19	0.54	0.16	0.04	0.55	0.13
November	1	0.00	0.00	0.03	0.01	0.00	0.00	0.01	0.00
Total	54	22.09	4.96	330.22	79.84	79.32	19.05	201.39	47.03

Source: Researcher’s fieldwork, 2012

Discussion

The months of July to September yielded the highest amount of erosional losses (runoff, sediment and nutrient losses) on all the plots. These months have also been reported by earlier studies. For instance, Okonkwo and Mbajiorgu (2010) identified July through September as months with highest daily rainfall. In a related study, Ologunorisa and Tersoo (2006) identified August as the month with the most frequent events of daily rainfall. This is not surprising as these months are usually associated with heavy rainstorms and more frequent rainfall events. Monthly runoff, sediment and nutrient losses on all the treatments were observed to increase with rainfall frequency. This makes rainfall a principal determinant of surface runoff across the fallow plots. This is consistent with the findings of Jiao et al., (2009) that rainfall amount has profound effects on erosional losses. The monthly quantity of sediment and nutrient losses recorded on the 5yr-old, 3yr-old plot and farmland was observed to increase with runoff depth. This is consistent with the observations of earlier and related studies, like those of Benik et al. (2003) and Egharevba (2004) that sediment yield generally increased with runoff depth.

The drastic increase in the density of herbaceous species (undergrowth) had considerable effects on the amount of runoff, sediment and nutrient loss experienced on the plots. This is because there was a drastic reduction in soil erosion with the growth in herbaceous cover on the 3yr-old fallow and cultivated farmland plots from the month of July to November. The rapid increase in the density of herbaceous species as well as the sprouting of cassava on the cultivated farmland following the full commencement of the rains helped to reduce erosional losses in the latter stage of the experiment. The high erosional losses experienced on the 5yr-old fallow was attributed to two reasons: (1) slow growth in herbaceous species due to previous land use history of unintended bush fire. The bush fire may have burnt the seedlings or propagules which probably affected the rapid establishment of herbaceous species that would have provided cover to the soil as obtained on the cultivated farmland; (2) the crown cover on the 5yr-old fallow was characterized by canopy gaps due to the density of shrubs. These reasons may be responsible for the high losses experienced on the 5yr-old fallow. The study reveals that the maintenance of adequate surface cover mostly ground cover (herbaceous species or undergrowth) during the months of July to September when heavy and frequent rainstorms are usually experienced will help to reduce soil erosion and its associated losses. A cursory look at the dynamics of erosional losses on the farmland shows that soil erosion and its associated losses take place on the onset of the rain and later reduce with the rapid growth of ground cover, hence, the careful management of soil erosion process at this time of the season deserves high priority to ensure the effective protection of farmlands (Pimentel, 2006). At the onset of the dry season, erosional losses reduced drastically mostly on plots with established vegetation characteristics (basically herbaceous cover and canopy cover). For instance, in November, a single rainstorm generated measurable runoff and eroded sediment. There were sporadic rainstorms, the rainstorms did not generate runoff across the plots as the amounts were >5 mm. The only rainfall event of 10.0 mm caused considerable losses in soil nutrient on the 5-year old and cultivated farmland plots. Since the experiment was carried out on uniform topography and soil types, the variations in runoff, sediment and nutrient losses on the plot treatments may be attributed to the differences in vegetation characteristics (herbaceous and canopy cover).

Conclusion

The study indicates that July to September experience the highest amount of losses of both runoff and sediment across the plots. This implies that surface mulching on fallows with scanty undergrowth and vegetation cover like the 5yr-old fallow should be carried out during these months to reduce unproductive loss of essential nutrient elements from the soil layer. The 5yr-old plot experienced the highest nutrient losses (OC: 52.2%, TN: 52.9%), followed closely by the cultivated farmland (OC: 31.8%, TN: 31.2%), while the 10yr-old and 3yr-old fallows experienced the lowest losses of 3.5%, 3.3% and 12.5%, 12.6% in OC and TN respectively. The study has shown that the age of fallow does not influence soil erosion process but the type and extent of surface cover available. The study suggests that weeding during the commencement of the dry season as it is usually practiced in this part of the world should be discontinued as it strips the soil of some protective cover for the subsequent season.

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