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Effects of cover management practices on Runoff and Erosion in Nsukka sandy loam soil

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Abstract

The effects of cover management and non-tillage on runoff and soil loss were investigated in 2004 and 2005 on runoff plots at the University of Nigeria Nsukka farm on a 5% slope of a sandy loam. Grass, legume, coco yam and sorghum were planted as conservation barriers in order to examine their influence on water and sediment transport. After each erosive storm for the two seasons, runoff and sediment yield were determined. The dense effective barriers (Panicum maximum and Centrosema pubescens) slowed down flow, retained water and prevented sediment yield. The less effective barriers with cocoyam, sorghum and control bare fallow allow flow of water and flow velocity was not reduced enough, resulting in water and soil transport. Cumulative runoff was highest in bare fallow (87mm) and lowest in sorghum (41mm). The highest soil loss of 1.13kg/m^2 and relatively low loss of 0.55kg/m^2 were obtained in cocoyam and sorghum in 2005. Runoff and soil loss were reduced by 100% under grass and legume. Cocoyam and sorghum reduced runoff by 20% and 53% respectively. Sorghum reduced soil loss by 35%, while there was no difference under the bare fallow and cocoyam. Runoff as percentage of rainfall was highest in bare fallow (60.6%) and lowest in sorghum (2.2%) respectively. Erosion rate calculated was lowest in sorghum (0.2kg/m^2/month) highest in cocoyam (0.41kg/m^2/month) and in bare fallow the value was 0.3kg/m2/month.

Key word: *cover management, non-tillage, soil loss, and runoff.*

Introduction

Soil erosion and land degradation are severe problems in West Africa (Lal, 1995). The main factor – directly or indirectly responsible for soil and land degradation process is water erosion (Spaan, 2005). Severe surface erosion is linked with intensive precipitation, high detachability of surface soil materials and reduced infiltration. This is induced by poor and weak soil structure and by poor cover of vegetation or plant residue in critical periods (Pla 1997). Most arable soils of the world suffered from serious problems of degradation due to high rate of runoff erosion (Piccolo et al., 1997). This has posed a great threat to agricultural sustainability in this region as it decreases actual and potential soil productivity (Lal 1998).

In the humid tropical region, the current increase in population has led to intensive cultivation of both low and uphill land, leaving the soil surface exposed to destructive effect of high energy rains with rapid organic matter depletion. In this fragile tropical environment, the extent of bare areas increases and the sustenance of biomass production is reduced (Valentine and Juneau 1989). Combating vegetation degradation either through natural grassland or planted crops has the potential to contribute directly to the maintenance and improvement of soil productivity. Vegetation cover protects the soil from intense precipitation of rain and detachability of surface materials. It reduces runoff, conserves moisture and retains sediment and organic debris. It also allows drainage of excess water due to their semi-permeable nature (Kiepe 1995). Runoff occurs whenever rain intensity exceeds the infiltration capacity of the soil, provided there are no physical barriers to rainfall flow. Estimation of runoff and erosion, tillage management and soil and water conservation plans are all based on precipitation data, soil properties and soil management. The assessment of the effect of cover management on hydrologic processes is important to support decisions on soil management. Land use should be properly planned taking into account, accurate estimates of surface runoff and subsequent soil loss produced under various farming practices. Many authors have stressed the positive effects of surface mulches produced by crop residues (Stone *et al*., 1996) and surface gravel or natural vegetation (Danalatos et al., 1998) in reducing runoff and erosion. Increased soil structural stability can also be achieved by reduced tillage (Rasmussen, 1999). This study evaluates effects of cover management on runoff and soil loss in Nkpologu sandy loam soil.

Materials and Methods

The experiment was carried out on fairly steep (5% slope) runoff plots established by Soil Science Department, University of Nigeria Nsukka, during the period 2004 – 2005. The runoff plots measured 20m x 3m and were spaced 50cm apart. Asbestos sheets were driven into the soil to a depth of 10cm along the top ends and side of the plot. The soil was well derived, sandy loam classified as typic paleustult (Nwadialo 1989). The area is located between latitude 06^{o} 51^{1}N and longitude 07o 24^{1}E, with mean elevation of 400m above sea level. The soil surface was kept free of weed and crust.

A complete randomized design (CRD) was used with five treatments and three replicates. The treatments were BF (bare fallow) CY (cocoyam) SG (sorghum), CP (Centrosema pubescens) Pm (Panicum maximum). Runoff was collected from the plots led by tin troughs placed at the down slope edge of each plot and then into large containers installed into the ground. The containers were emptied after each rainfall events, runoff water measured and sediment sample taken after weighing. The total weight of sediment was estimated by calculation. Cocoyam and sorghum were planted with a careful opening of soil by hoe; *Centrosema pubescens and Panicum maximum* were established through seedling. Rainfall-runoff relationships were determined and erosion rate calculated. Cumulative runoff and soil loss were graphically represented.

Result and Discussion

Run off and soil loss under various management practices

The total rainfall for two months (September and October) of data collection was 568mm in 2004. For a three month period (August – October) of monitoring in 2005 the amount was 634mm. Run off and soil loss as affected by different management practices are presented in Figures 1, 2, 3 and 4.

In 2004, erosion was observed on bare fallow and on all other plots. Runoff and soil loss varied with the management practices (Figure 1 and 2). Runoff quantities under bare fallow, legume, cocoyam, sorghum and grass treatments were 35mm, 36mm, 27mm, 24mm and 13mm respectively. The corresponding soil loss values were 0.44 $kglm^2$ 0.61 kg1m2, 0.41 $kglm^2$, 0.33 $kglm^2$ and 0.08 $kglm^2$ respectively. The highest runoff and erosion values were obtained under legume (CP) and bare fallow (BF) plots. Notably there was poor cover establishment in the legume plots, during the first year of the experiment.

In 2005, there were no runoff and soil loss on the PM and CP plots which were effectively covered (Figures 3 and 4). These management practices apparently provided sufficient canopy vegetation to dissipate the energy of the rainstorms (Obi, 1982). With reduced rainfall impact water infiltration rate was greatly enhanced in these plots. No runoff or soil loss would be expected where infiltration rate exceeds the rainfall intensity.

The highest runoff of 87mm (Figure 3) was observed under the bare soil treatment followed by the runoff under cocoyam and sorghum with 65mm and approximately 41mm respectively. The highest soil loss of 1.13$kglm^2$ was obtained under cocoyam plots followed by losses under bare soil and sorghum (0.77 $kglm^2$ and 0.5 $kglm^2$ respectively). The order of soil loss was as follows: CY>BF> SG. Runoff and soil loss were high in the in 2005 compared to 2004, reflecting apparently the prevailing rainfall characteristics.

In Figure 4, it could be observed that bare fallow treatment resulted in less soil loss compared to the cocoyam cultivation, despite the high volume of runoff (Fig 5). This might be as a result of the crusted surface in bare fallow plots. More and Singer (1990), noted that decreases in soil loss were accompanied by increase in water erosion and suggested that decreased soil erodibility was associated with crust formation.

The grass and Legume treatments completely reduced both soil loss and runoff by 100% while cocoyam and sorghum cultivation reduced runoff by 25.8% and 53% respectively in 2005. Sorghum reduced soil loss by 35% while there was no difference in soil loss under the bare fallow and cocoyam treatments.

Table 1 shows runoff as percentage of rainfall in 2005. The lowest percentages obtained under BF, CY and SG were 2.8, 2.2, and 2.3 respectively, whereas the highest percentages were 60.6, 31.6 and 19.8 respectively. Runoff as percentage of rainfall showed non-significant correlation with rainfall amount. Spaan (2005) reported a poor relationship between rainfall and percentage of runoff.

Table 1 Runoff as a percentage of rainfall

		(Runoff/Rainfall) %				
2005	Rainfall (mm)	BF	CY	SG	CP	PM
8-Nov	33.8.	2.8	2.3	2.2	-	-
28/Aug	17.5	5.9	3.7	3.8	-	-
9-May	41.7	19.5	16.5	10.8	-	-
9-Jun	6.9	3.9	-	4.4	-	-
9-Oct	22.4	4.6	4.4	4	-	-
9-Nov	8.1	11.4	12.2	11.3	-	-
18/Sept	24.1	4.1	4.1	3.8	-	-
21/ Sept	8.9	10.6	9.9	10.1	-	-
24/ Sept	53.9	12.9	6.3	6.5	-	-
22/Aug	12.5	8	8	8	-	-
26/ Sept	39.4	18.2	8.3	9.3	-	-
27/ Sept	10.2	10	9.8	9.7	-	-
10-Mar	27.9	3.9	3.8	2.5	-	-
10-May	50.3	30.6	31.6	2.1	-	-
10-Jun	43.4	19.8	17.8	7.6	-	-
10-Jul	41.9	20.3	15.9	9	-	-
10-Oct	17.5	5.9	5.4	3.8	-	-
22/Oct	9.4	60.6	19.3	7.5	-	-
31/Oct	16	5.9	5.1	2.3	-	-

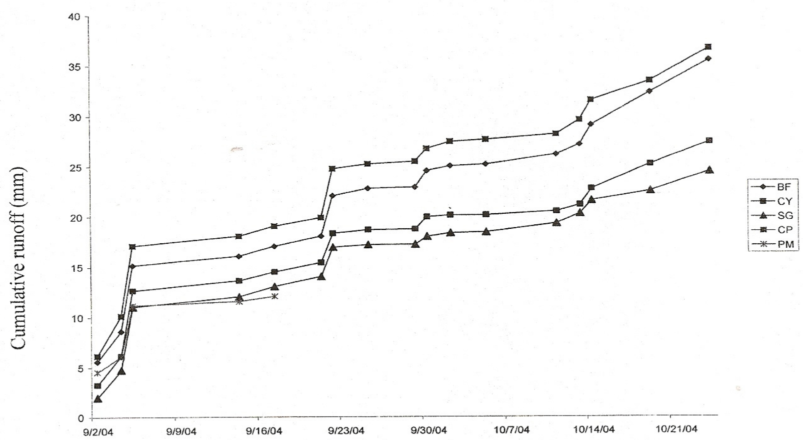

Fig 1. Cumulative runoff on different date in 2004

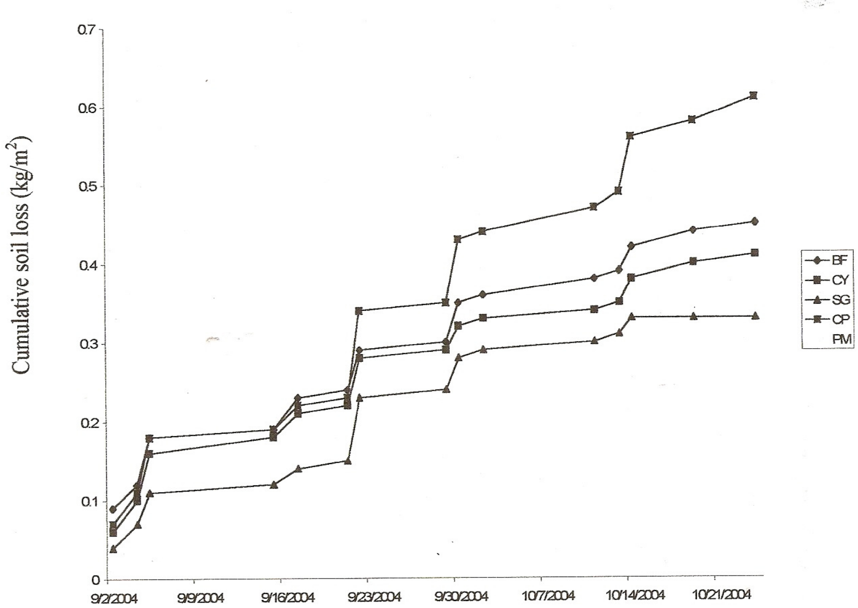

Fig 2. Cumulative soil loss on different date in 2004

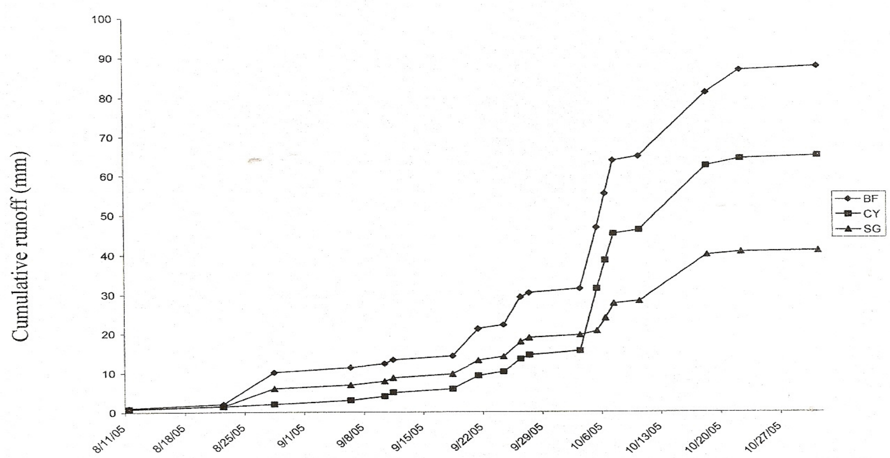

Fig 3. Cumulative runoff on different date in 2005

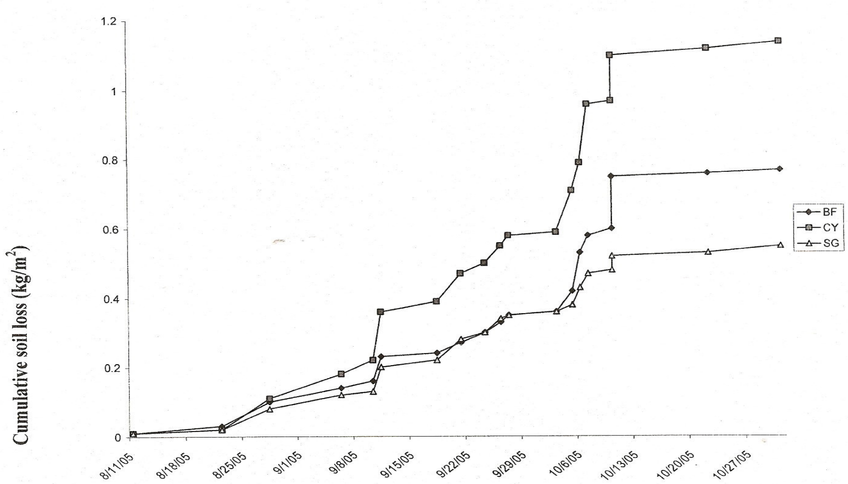

Fig 4. Cumulative Soil loss on different date in 2005

Erosion rate under the management practices

Erosion rate in terms of sediment loss was calculated for the three months as shown in Table 2. Sorghum cropping resulted in lower erosion rate of 0.2kg/m^2/month, compared to cocoyam cultivation with rate of 0.4kg/m^2/month whereas under bare fallow treatment the rate was 0.3kg/m^2/month. The erosion rates were small compared to soil loss tolerance rate of 1.05kg/m^2. Therefore, erosion rate of 0.2 and 0.4kg/m^2/month may not adversely affect the soil surface. The erosion was zero under PM and CP.

Table 2: Erosion rate (kg/m^2/month) under different management practices, in 2005.

Months	BF	CY	SG	CP	PM
August	0.1	0.1	0.1	00	00
September	0.3	0.5	0.3	00	00
October	0.4	0.6	0.2	00	00
Mean	0.3	0.4	0.2	00	00

BF = Bare fallow CY = cocoyam SG = Sorghum CP = *Centrosema pubescens*
PM = *Panicum maximum*

Conclusion

The result of this study demonstrated the potentials of cover management practices in reduction of runoff and soil losses. Where runoff and soil loss were not completely stopped, they were reduced to tolerable level. The runoff percentage was higher in bare fallow compared to the less protective barriers.

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