EFFECT OF FIELD SLOPES AND MULCH RATES ON RUNOFF AND SOIL LOSS IN OWERRI, NIGERIA

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ABSTRACT

Simulated rainfall was used to determine quantitatively the effect of field slopes and mulch rates on runoff and soil loss in Owerri, Nigeria. The results obtained show that soil loss and runoff significantly increased with increase in field slope, and were reduced with successive increase in mulch application. The bare plot yielded 0.22t/ha soil loss and no runoff on 2% slope; 12.58t/ha soil loss and 564m3/ha runoff on 9% slope and 18.42t/ha soil loss and 870m3/ha runoff on 15% slope. The possible minimum desirable mulch (Panicium maximum) cover required to protect the soil at 2% slope is 5t/ha. The 5t/ha mulch cover reduced soil loss by 76% and runoff by 64% on 9% slope, and by 76% and 56% respectively on 15% slope when compared to the bare plots. Better results were achieved with 10t/ha mulch cover on each slope. However, based on the generally recommended mulch rate of 4-6t/ha for the tropics, the study recommends 5t/ha mulch cover as the desirable and most cost effective rate for controlling erosion on sloping loamy sand soil of Owerri, Nigeria.

KEYWORDS: Slope, mulch, runoff and soil loss

1. INTRODUCTION

Recent increase in human population has placed a great strain on the world's soil systems. More than 5.5 billion people are now using about 10% of the land area of the earth to raise crops and livestock (Gow and Pidwirny, 1996). These agricultural activities on land expose it to various types of degradation that can ultimately reduce its productivity and general usefulness. Soil erosion caused by water has been identified as an age long problem since man started settling down and carrying out farming activities. This type of erosion occurs mostly, on bare-sloped lands, especially when exposed through tillage activities to the impact of rainfall.

In Nigeria, especially in the southeastern zone, agricultural activities (crop production) are controlled by the time of start, duration and end of the rainy season. Land preparation such as bush clearing and burning and planting on mounds devoid of any form of vegetal cover is practiced in this region. The planted staple food crops (cassava, yam, maize and groundnut) and certain industrial crops (such as banana and pineapple) are incapable of covering the soil sufficiently before the critical period (Roose, 1996). Thus the bare farmlands are exposed to the intense violent rainstorm, which characterize the southeast. The erosion hazard, as a result, is extreme. Over 50% of the cultivatable lands in Southeastern Nigeria are affected by severe soil erosion (Braide, 1982), and the amount of soil that is lost as a result of water erosion alone in Nigeria is in the magnitude of millions of tons annually (Amba, 1991). Mbagwu et al. (1984) reported a large yield reduction resulting from the removal of 5 to 20cm topsoil by splash erosion.

Splash erosion steadily reduces yield and is by far the worst type of soil erosion affecting more than 95% of the land area of the southeast (Igbozurike, 1990). Yet, this most pernicious type of soil erosion hardly attracts news media headlines, nor is it ever mentioned as a problem by the numerous rural communities, which vocally complain about the onslaught of gully erosion on their land (Igbozurike, 1990). Soil has always been, as it is now and will likely remain, the major source of human sustenance (Timmons, 1980).

Implementing appropriate erosion management techniques on farmland is therefore essential; bearing in mind that the most effective soil conservation technique may be of little benefit unless farmers extensively apply it. Peasant farmers therefore, need management options that can be easily incorporated into their existing farming systems. Surface mulch has been shown to be tremendously effective in controlling erosion on sloping farmland (Lal, 1976 and Aina, 1993). However, there is the need to determine the quantity required for optimum control of soil erosion. Furthermore, a continual build up of information on the effect of slopes and their interaction with different mulch rates on runoff and soil loss in Southeastern Nigeria is invaluable in our continuing efforts toward sustainable crop production on sloping farmland. This paper therefore examines the effect of slope and their interaction with different mulch rates on runoff and soil loss.

2. MATERIALS AND METHODS

The experiment was conducted at the Erosion Research Centre, Federal University of Technology Owerri (FUTO) Imo State. The experimental site (100m by 200m) was cleared manually and experimental plots (1.0m by 1.5m) were laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The soil is loamy sand with manually made slopes of 2, 9 and 15%; which were selected based on the natural gradient of the study area and mulch (*panicium maximum*) rates of 0, 5 and 10t/ha giving a total of 27 micro plots.

A portable drip type rainfall simulator (Bowyer-Bower and Burt, 1989) with plot frame (soil tray) dimension of 1.0m by 0.5m, at 2.0m height above the soil surface was used insitu in the study (see plate 1). The simulated rainfall intensities range from 23mm/h to 84mm/h, however 57 and 84mm/h which are within the Imo State range of most occurring rainfall intensity were used in this study. The 57mm/h simulated rainfall intensity was run for one hour to preliminary wet the soil. The runoff was collected and the plot was left for 24hours before initiating a second trial the after (Hudson, 1993). The second simulated rainfall on the same plot lasted for 30minutes with 84mm/h rainfall intensity. Almost immediately (after about 5minutes) another 30minutes "very wet" run of 84mm/h intensity was carried out to complete the erosion test on the micro plot. The same procedures were repeated on each micro plot. A flocculent $Al_2 (so_4)_3 \times H_2O$ (Alum), was added to the collected runoff to settle suspended materials (Jackson, 1964) and the clear supernatant liquid was measured with graduated cylinder. The remaining sludge was oven dried to determine the dry weight of soil loss.

The results obtained from the erosion test were subjected to statistical analysis using Analysis of Variance (ANOVA). Detection of differences between treatment means for significant effects were obtained using Fisher's Least Significant Difference (F-LSD) procedure at 5% level of probability (Obi, 2002).

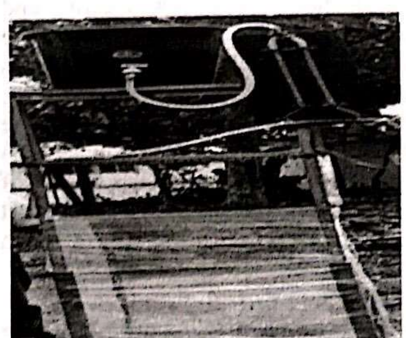

Plate 1. Rainfall simulator in place during the field experiment

3. RESULTS AND DISCUSSION

The mean effect of slope and mulch rate on runoff and soil loss under the three-soil moisture condition is presented in Tables 1 to 6. Runoff and soil loss under the different soil moisture conditions significantly ($p \leq 0.05$) increased with successive increase in slope. The highest volume of runoff (m^3/ha) and soil loss (t/ha) was on 15% slope. On 2% slope there was no runoff, however small quantity of soil (t/ha) was lost through splash effect.

Table 1. Mean effect of slope and mulch rate on runoff (m^3/ha) under initial dry soil condition

	Levels	Runoff (m^3/ha) Slope (%) <2	9	15	Mulch mean
Mulch (ton/ha)	0	0.00(0.707)*	79.333(8.932)	101.667(10.108)	60.333 (6.582)
	5	0.000(0.707)	6.133(2.576)	30.467(5.564)	12.200(2.949)
	10	0.000(0.707)	2.453(1.716)	11.267(3.425)	4.573(1.949)
Slope mean		0.000(0.707)	29.306(4.408)	47.800(6.366)	

F -LSD$_{(0.05)}$ for comparing two mulch mean is 0.140
F -LSD$_{(0.05)}$ for comparing two slope mean is 0.140
F -LSD$_{(0.05)}$ for comparing two slope and mulch interaction mean is 0.242
* Figures in parenthesis are transformed data to which LSD is applied

Table 2. Mean effect of slope and mulch rate; on soil loss (t/ha) under initial dry soil condition.

	Levels	Soil loss (t/ha) Slope (%) <2	9	15	Mulch mean
Mulch (ton/ha)	0	0.100(0.775)*	1.925(1.557)	2.589(1.758)	1.538(1.363)
	5	0.000(0.707)	0.026(0.725)	0.115(0.784)	0.047(0.739)
	10	0.000(0.707)	0.000(0.707)	0.000(0.707)	0.000(0.707)
Slope mean		0.033(0.730)	0.650(0.996)	0.901(1.083)	

F -LSD$_{(0.05)}$ for comparing two mulch means is 0.006
F -LSD$_{(0.05)}$ for comparing two slope mean is 0.006
F -LSD$_{(0.05)}$ for comparing two slope and mulch interaction mean is 0.010

Table 3. Mean effect of slope and mulch rate; on runoff (m^3/ha) under wet soil condition.

	Levels	Runoff (m^3/ha) Slope (%) <2	9	15	Mulch mean
Mulch (ton/ha)	0	0.000(0.707)*	121.000(11.022)	330.00(18.179)	150.333(9.969)
	5	0.000(0.707)	89.133(9.467)	148.800(12.216)	79.311(7.463)
	10	0.000(0.707)	49.267(7.054)	82.533(9.112)	43.933(5.624)
Slope mean		0.000(0.707)	86.467(9.181)	187.111(13.169)	

F -LSD$_{(0.05)}$ for comparing two mulch means is 0.158
F -LSD$_{(0.05)}$ for comparing two slope mean is 0.158
F -LSD$_{(0.05)}$ for comparing two slope and mulch interaction mean is 0.273

Table 4. Mean effect of slope and mulch rate; on soil loss (t/ha) under wet soil condition

	Levels	Soil loss (t/ha) Slope (%) <2	9	15	Mulch mean
Mulch (ton/ha)	0	0.083(0.764)*	3.920(2.103)	4.853(2.314)	2.952(1.727)
	5	0.000(0.707)	1.041(1.241)	1.481(1.408)	0.841(1.119)
	10	0.000(0.707)	0.419(0.952)	0.769(1.126)	0.39(0.928)
Slope mean		0.028(0.726)	1.793(1.432)	2.368(1.616)	

F -$LSD_{(0.05)}$ for comparing two mulch means is 0.014
F -$LSD_{(0.05)}$ for comparing two slope mean is 0.014
F -$LSD_{(0.05)}$ for comparing two slope and mulch interaction mean is 0.025

Table 5. Mean effect of slope and mulch rate on runoff (m^3/ha) under very wet soil condition

	Levels	Runoff (m^3/ha) Slope (%) <2	9	15	Mulch mean
Mulch (ton/ha)	0	0.000(0.707)*	363.930(19.083)	438.130(20.942)	267.353(13.577)
	5	0.000(0.707)	131.470(11.486)	191.070(13.839)	107.513(8.677)
	10	0.000(0.707)	74.670(8.667)	121.000(11.022)	65.223(6.799)
Slope mean		0.000(0.707)	190.023(13.079)	250.067(15.268)	

F-$LSD_{(0.05)}$ for comparing two mulch means is 0.601
F-$LSD_{(0.05)}$ for comparing two slope mean is 0.601
F-$LSD_{(0.05)}$ for comparing two slope and mulch interaction mean is 1.041

Table 6. Mean effect of slope and mulch rate on soil loss (t/ha) under very wet soil condition.

	Levels	Soil loss (t/ha) Slope (%) <2	9	15	Mulch mean
Mulch (ton/ha)	0	0.026(0.725)*	6.738(2.690)	10.973(3.386)	5.912(2.267)
	5	0.00(0.707)	1.386(1.373)	1.934(1.560)	1.107(1.213)
	10	0.00(0.707)	0.778(1.130)	1.097(1.264)	0.625(1.034)
Slope mean		0.009(0.713)	2.967(1.731)	4.668(2.070)	

F -$LSD_{(0.05)}$ for comparing two mulch means is 0.035
F -$LSD_{(0.05)}$ for comparing two slope mean is 0.035
F -$LSD_{(0.05)}$ for comparing two slope and mulch interaction mean is 0.060
*Figure in parenthesis is transformed data to which LSD is applied.

Increase in the application of mulch significantly resulted in a significant decrease in the volume of runoff and soil loss. The interaction between the mulch rate and slope was significant. On 2% slope, there was no significant difference among the mulch rates as there was no runoff. However, on 9 and 15% slope, the mulch rate (5 and 10t/ha) significantly ($p \leq 0.05$) reduced the soil loss and runoff volume relative to the control (0t/ha mulch). The least volume of runoff and soil loss was obtained with 10t/ha mulch cover.

Runoff volume and the quantity of soil loss significantly increased with increase in the slope gradient of the test plots. This agrees with the findings of most previous investigators like Lal (1976), Jo (1991), Schwab *et al.*, (1992) and Osunbitan and Adekalu (1997). The bare- plot (no mulch) at 15% slope had the largest volume of runoff and highest quantity of soil loss. This is because steep slope increases runoff velocity and the movement of sediment carried in the runoff. The measured soil loss was 0.22t/ha on bare flat plot, 12.58t/ha on 9% slope and 18.42 t/ha on 15% slope.

The application of mulch substantially reduced the quantity of soil loss at each slope. This result is expected and thus confirms the finding of other researchers like (Lal, 1976; Roose, 1988; Aina, 1993; Becher, 2003). There was no soil loss at 2% slope (flat bed), when the soil was covered with mulch (5t/ha) under the different soil moisture conditions. However on 9 and 15% slopes, soil loss and runoff were significantly reduced with 5t/ha mulch rate, although a better result was obtained with 10t/ha mulch rate. This suggests 5t/ha as the possible minimum desirable mulch cover required to protect the soil.

4. CONCLUSION

The mulch rates (5 and 10t/ha) were very effective in controlling erosion on moderate to steep slope (2, 9 and 15%). Although the 10t/ha mulch is significantly better than the 5t/ha mulch rate, however, the 5t/ha mulch cover is recommended as a desirable most cost effective mulch rate for controlling erosion on sloping loamy sand soil in Owerri, Imo State. The choice of 5t/ha mulch rate is also based on the general recommended mulch rate of 4-6t/ha for the tropics. The study clearly reflects the importance and role of mulching in controlling erosion hazards in Owerri, Nigeria.

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