Utilization of Palm-mat Geotextiles to Conserve Agricultural Soils

Ranjan Bhattacharyya
PhD Student
School of Applied Sciences, The University of Wolverhampton, Wulfruna Street, Wolverhampton
WV1 1LY, UK, phone: 0044-1902-322134, fax: 0044-1902-322680, e-mail: ranjan_vpkas@yahoo.com

Kathy Davies
Ex-researcher
School of Applied Sciences, The University of Wolverhampton, Wulfruna Street, Wolverhampton
WV1 1LY, UK.

Michael A. Fullen
Professor of Soil Technology
School of Applied Sciences, The University of Wolverhampton, Wulfruna Street, Wolverhampton
WV1 1LY, UK, phone: 0044-1902-322410, fax: 0044-1902-322680, e-mail: m.fullen@wlv.ac.uk

Colin A. Booth
Senior Lecturer in Environmental Engineering
School of Engineering and the Built Environment, The University of Wolverhampton, Wulfruna Street,
Wolverhampton WV1 1LY, UK, phone: 0044-1902-518562, fax: 0044-1902-322680, e-mail:
c.booth@wlv.ac.uk

BIOGRAPHY OF AUTHORS

Ranjan Bhattacharyya, M.Sc., is a Scientist (on study leave) from the Indian Council of Agricultural Research (ICAR). His research activities are mainly concerned with soil conservation and carbon sequestration and his fieldwork is mainly based in Asia and the UK. He has authored one bulletin, six book chapters, 13 refereed papers in international journals, 10 refereed papers in Indian national journals, and 13 conference papers. He is a referee for three international journals and two Indian national journals. He received an ICAR Fellowship, Junior Research Fellowship awarded (by ICAR) during his B.Sc. and M.Sc., respectively. In 2007, he was awarded one of the 'Best Young Researchers Awards' by the European Society for Soil Conservation (ESSC).

Dr Kathy Davies earned her B.Sc. degree in Environmental Science awarded by the University of Wolverhampton, UK (2001). In 2005, she was awarded a posthumous Ph.D. degree from the same Institution. Her research activity was concerned with soil erosion and use of palm-mat geotextiles to conserve soils. She developed an excellent idea to construct geotextiles mats from the leaf of *Borassus aethiopum* and structurally-similar species and to use them for soil conservation. That original idea laid the foundation of the BORASSUS Project (2005-2009), which was funded by the European Commission. She had authored in two refereed papers in international journals and five conference papers.

Professor Michael A. Fullen, Ph.D., mainly works in soil erosion, soil conservation and desert reclamation. He has authored one book, 142 refereed papers, 178 conference papers and 24 consultancy reports. He is also Honorary Professor at Yunnan Agricultural University, China, and an Academician of the Lithuanian Academy of Sciences. He is a referee for 28 journals and a member of the Editorial Board of 'Geomorphology,' The 'World Association of Soil and Water Conservation' (WASWC), and four other journals. He has jointly supervised 19 Ph.D. theses to completion and been Examiner for 17 Ph.D. theses. He is Vice-President of the WASWC, Vice-President and Editor-in-Chief of the ESSC and is a Fellow of the Royal Geographical Society.

Dr Colin A. Booth is a Senior Lecturer in Environmental Engineering at the School of Engineering and the Built Environment, The University of Wolverhampton. He gained his Environmental Science Ph.D. in 2002 from The University of Wolverhampton (UK). He has published nearly 50 scientific papers and chapters as a lead author/co-author. His main research interests are in the following areas: environmental magnetism, soil erosion and conservation, soil management, water engineering and management, urban pollution and epidemiology, coastal and estuarine science.

ABSTRACT

Previously, most studies on the effectiveness of geotextiles on soil erosion rates and processes were conducted in laboratory experiments for <1 h. Hence, at Hilton (52°33' N, 2°19' W), East Shropshire, UK, we investigated the effectiveness of employing palm-mat geotextiles (Borassus and Buriti mats) to reduce rainsplash erosion, runoff and soil loss under field conditions. This study is a component of the European Union-funded BORASSUS Project. The effects of Borassus mats on rainsplash erosion were studied for ~2 years (2002-2004), and re-established in January 2007 on a 0° slope. There were 12 experimental plots (six plots completely-covered with mats and six bare plots; each measuring 1.0 x 1.0 m). Runoff-plot studies were also conducted on the loamy sand soil at Hilton for 2 years (2002-2004) with duplicate treatments: (i) bare soil; (ii) grassed, (iii) bare soil with 1 m Borassus-mat buffer zones at the lower end of the plots and (iv) completely-covered with Borassus-mats. Each plot was 10 x 1 m on a 15° (26.6%) slope. To confirm the results, another set of experiments have been in progress at Hilton since January 2007, with one additional treatment (bare soil with 1 m Buriti-mat buffer zones) compared with the earlier experiment. Runoff and soil erosion were collected from each plot in a concrete gutter, leading to a 0.02 m^3 (20 liters) capacity receptacle placed inside a 0.14 m^3 (140 liters) capacity container. Results (06/10/02-02/09/04; total precipitation = 1038.3 mm) showed Borassus mats on bare soil reduced total rainsplash erosion by ~50% compared with bare plots (9.64 kg m^{-2}; 1.97 lb ft^{-2}). The use of Borassus mats on bare soil (during 01/22/07-01/21/08; total precipitation = 919.2 mm) also reduced soil splash erosion by ~90%. During 03/25/02-05/10/04 (total precipitation = 1319.8 mm) complete cover of Borassus mats on bare soil reduced total runoff by ~19% and soil erosion by ~64%. Furthermore, Borassus mats as 1 m buffer strips on bare soil reduced runoff by ~36% and soil erosion by ~57%. During 01/08/07-01/14/08 (total precipitation = 923.4 mm), plots with Borassus and Buriti mats as buffer strips on bare soil reduced sediment yield by ~93 and 98%, respectively, and runoff by ~83 and 63%, respectively. Buffer strips of Borassus mats were also as effective as complete cover of the same mats. Thus, utilization of palm-mat geotextiles as buffer strips on bare plots (area coverage ~10%) is highly effective for soil and water conservation.

KEYWORDS: Palm-mat geotextiles; buffer strips; soil erosion control; rainsplash erosion; runoff

Utilization of Palm-mat Geotextiles to Conserve Agricultural Soils

Ranjan Bhattacharyya, Kathy Davies, and Michael A. Fullen

School of Applied Sciences, The University of Wolverhampton, Wulfruna Street, Wolverhampton WV1 1LY, UK

Colin A. Booth

School of Engineering and the Built Environment, The University of Wolverhampton, Wulfruna Street, Wolverhampton WV1 1LY, UK

1.0 INTRODUCTION

Soil erosion is widespread and adversely affects all human-managed ecosystems, including agriculture and forestry. The extent and severity of erosion on European soils have markedly increased over the last 50 years, particularly on arable land (Davies et al., 2006). The rate of erosion in Europe is ~10-25 Mg ha^{-1} yr^{-1} (Boardman, 1998). Annual erosion rates on cultivated land vary from 0.1 to 20 Mg ha^{-1} in the UK (Morgan, 1986). Since growing high value crops (e.g. potatoes, sugar beet) provides less protection to the soil than cereal production, especially where two crops per year are obtained, erosion rates on these lands are likely to be high. Again, in Western Europe, there is a period in mid-summer when the land is bare at the time of high-intensity thunderstorms, when soil loss rates ≤ 19.5 kg m^{-2} (3.99 lb ft^{-2}) have been reported due to a single storm (Morgan, 1985). With projected global climate changes, the likelihood of high soil erosion rates will further increase (Boardman and Favis-Mortlock, 1993).

A fully mature vegetation cover with a uniform and dense sward is generally able to reduce soil erosion considerably compared to bare soil (Rickson, 2006). However, establishment of a fully mature vegetation may take one to two seasons (Hann and Morgan, 2006). This period has normally high erosion risk as roots, stems and plant canopy will be insufficiently developed to reduce soil loss. Without immediate and appropriate protection, slopes can suffer from severe soil loss and instability, which in turn makes vegetation establishment extremely difficult (Vishnudas et al., 2006). Erosion control mats and blankets or geotextiles offer immediate soil protection during the transitional period between germination/planting and full maturity (Rickson, 2006) and once installed, these products may remain in place for several months, or even years, and serve as composite erosion control solutions (Davies, 2000).

Erosion control geotextiles are made from natural (jute, coir, sisal, cereal straw and palm leaves) or synthetic (nylon, polypropylene, polyester and polyethylene) materials (Rickson, 2006). Despite synthetic geotextiles dominating the commercial market, geotextiles constructed from organic materials are highly effective in erosion control and vegetation establishment (Langford and Coleman, 1996). Studies have shown that natural fibers were more effective than synthetic ones in controlling erosion (Sutherland and Ziegler, 1996) and were the preferred method because of their 100% biodegradability and better adherence to the soil (Langford and Coleman, 1996). Moreover, synthetic geotextiles can cost over 10 times as much per unit area as natural ones (Ingold, 1996). The material composition of geotextiles determines their longevity in the field: natural products last about two to five years, whereas synthetic products last over 25 years (Oosthuizen and Kruger, 1994). However, it is argued that once vegetation is established on-site, geotextiles become redundant in terms of erosion control. As they degrade, natural products add organic matter and nutrients to the soil, which may enhance soil microbiological activity, fertility and aggregate stability (Rickson, 2006).

Geotextiles constructed from leaves *of Borassus aethiopum* (black rhun palm of West Africa) and *Mauritia flexuosa* (Buriti palm of Latin America) are termed Borassus and Buriti mats, respectively. Borassus mats were first constructed in The Gambia (Plate 1) and the Buriti mats in Brazil (Plate 2). They meet selected criteria (simple and cost-effective to manufacture and provide immediate erosion control). Palm-mat geotextiles could be constructed at an economically viable price of $0.35-0.45 per square meter, which is comparable to other geotextiles (Davies et al., 2006). As covering bare soil completely with palm-mat geotextiles would not be economically viable, there is need to evaluate soil detachment rates after utilization of palm-mat geotextiles as buffer strips. Available studies do not allow quantification of the effectiveness of palm-mat geotextiles in decreasing water erosion (runoff and sediment yield). Moreover, most previous studies on the effectiveness of geotextiles for soil conservation were conducted in laboratory experiments for <1 h. Therefore, we hypothesize that buffer strips of Borassus mats would be as effective as complete cover of the same mats in conserving soils. Another hypothesis tested in this study was: buffer strips of Borassus mats would be more effective than buffer strips of Buriti mats in erosion control, as Borassus mats possess better physical properties (i.e. greater thickness and mass per unit area and less percent open area than Buriti mats).

Plate 1. A Borassus mat manufactured at The Gambia.

Plate 2. Buriti mats after their manufacture in Brazil.

1.1 Objectives

The objectives of the studies were: (i) to learn the potential of using palm-mat geotextiles (Borassus and Buriti mats) for soil conservation, (ii) to determine the effectiveness of Borassus mats on rainsplash erosion, and (iii) to compare efficacy of complete cover of Borassus mats with buffer strips of the same mats and buffer strips of Borassus mats with buffer strips of Buriti mats for soil and water conservation.

2.0 MATERIALS AND METHODS

2.1 Site

Investigations were conducted at the Hilton Experimental Site, east Shropshire, U.K. (52.0^{o}33'5.7" N, 2.0^{o}19'18.3" W; NGR SO778952), within the southern section of the Worfe Catchment, a tributary of the mid-Severn (Fullen and Reed, 1986). The region experiences a temperate climate with a mean annual precipitation of 620.0 mm (Std. Dev. = 104.9, n = 15 years). In most of the area, the Permo-Triassic sandstones are overlain by a suite of glacial and proglacial sediments (Hollis and Reed, 1981). Most soils (FAO/UNESCO classification: Dystric Cambisol) belong to the Newport and Bridgnorth Associations, which total 2593 km^2, equivalent to 1.7% of the surveyed area of England and Wales (Fullen and Reed, 1986).

2.2 Splash Erosion

Twelve (1 x 1 m; 3.28 x 3.28 ft) plots were established in 2002 at Hilton to study the effects of Borassus mats on splash erosion during 2002-04 and they were re-established in 2007 (Plate 3). Based on analysis of soil samples (0-0.05 m; 0-0.164 ft) collected in June 2002, the soil was loamy sand (Davies et al., 2006). The design and treatment combinations of both experiments (2002-04 and 2007-08) were similar. Six randomly-selected plots were completely covered with Borassus mats, and the rest were bare. The slope gradient used in these tests was kept constant (0^o), as rainsplash erosion can occur even on flat surfaces, due to the trajectory of raindrop splash impacts (Morgan, 2005). The soil was prepared by rotavating and removing grass turfs and raking the surface. The mats were cut with a secateaurs at one end very carefully and placed over the soil surface and attached with pegs. All plots were maintained in a bare condition by regular 'Roundup' (isopropylamine salt of N-phosphonomethyl glycine) herbicide treatments. In January 2007, the soil (0-0.05 m; n = 12) had 50.2% sand (2000-60 μm), 45.5% silt (60-2 μm), 4.3% clay (< 2 μm) and mean (n = 12) soil pH was 5.48 (± 0.08) and mean (n = 12) soil organic matter (SOM) was 2.82% (± 0.34%).

Soil splash was measured in each plot by collecting splashed particles in a centrally-positioned trap during 06/10/02-02/09/04 and again during 01/22/07-01/21/08. Each trap consisted of a 0.152 m (~0.49 ft) diameter circular tube inserted into the soil, containing a similar-sized funnel on top of a 0.001 m^3 (1 liter) bottle (Plate 4). They were installed 0.01 m (~0.03 ft) above the soil surface, thus, only allowing splashed soil particles to enter. Comparable splash traps have been used by Poesen and Torri (1988). The splashed particles were carefully washed from plastic funnels. The collecting bottles were emptied after substantial rain and trapped fauna removed using a 2.0 mm (0.007 ft) sieve in the laboratory, then the splashed particles were dried overnight at 40°C and weighed. There is an experimental bias in measuring soil splash detachment (van Dijk et al., 2002). The measured rates of soil splash detachment are only the apparent rates and depend on the size distribution of the splashed soil particles and geometry of the experimental device (Nanko et al., 2008). The quantity of splashed material measured per unit area was corrected after Poesen and Torri (1988) using the equation:

$$MSR = MS\ e^{0.054D} \quad [1]$$

where MSR is the corrected mass of splashed material per unit area (kg m^{-2}; lb ft^{-2}), MS is the measured splash per unit area (kg m^{-2}; lb ft^{-2}) and D is the funnel diameter (m; ft). Since all splash traps had the same geometry, device-related size bias was neglected. Funnel diameter influences the amount of eroded soil collected. A ≥ 0.1 m (≥ 0.33 ft) diameter funnel was recommended to collect soil splash erosion (Poesen and Torri, 1988). Furthermore, the fraction of the total mass of detached sediment that splashes > 0.5 m (~1.64 ft) generally represents < 5% (Savat and Poesen, 1981). Hence, the size of individual plot was kept at 1 x 1 m (3.28 x 3.28 ft) and adjacent areas of the plots were separated with concrete plinths (0.15 m; 0.49 ft width).

Splash height (m; ft) was measured using trapped particles on 0.5 m (~1.64 ft) high wooden pegs, painted with 'Polaguard' plastic paint to aid measurements and 10 height zones, each 0.05 m (0.164 ft) high, were indicated. Each plot had one splash peg, positioned on the north-eastern diagonal, halfway between the splash trap and the corner post. It is logical that the single position of the splash boards would cause bias, due to wind direction. However, we did not install 3-4 splash height boards within a plot, as that might affect the trapped amount of splashed sediment in the cups. Hence, the assumption was made that bias of measuring splash height (by a single splash board) due to wind direction would have been similar for all treatments and would not affect the relative behavior of mat-covered plots compared with bare plots.

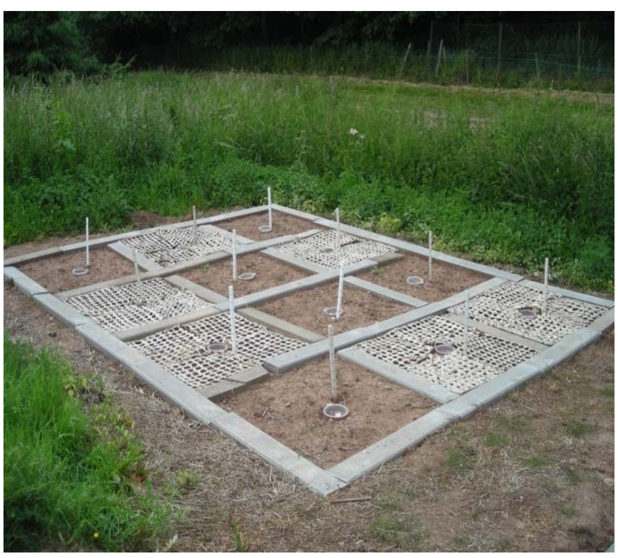

Plate 3. Splash experimental plots at Hilton, UK (01/22/2007).

Plate 4. Plan view of a scale and splash collector.

2.3 Runoff Plots

Eight runoff plots [situated on a 15° (26.6%) south-west facing slope, numbered D1-D8 and measuring 10 x 1 m] were established in 2002 (Figure 1a) to study the effectiveness of Borassus mats on runoff volume and soil loss. In January 2002, the soil (0-0.05 m; 0-0.164 ft) had a mean (n = 80) SOM of 3.83% (± 0.57%). Using random selection, plots D2 and D8 were completely covered with Borassus mats, D4 and D5 had 1 m buffer zones of Borassus mats at the plot lower end, D1 and D6 were the bare soil (control) plots and D3 and D7 were grassed plots. The plots were bordered with black plastic lawn-trim, with 0.1 m (0.33 ft) intruding into the soil and 0.1 m (0.33 ft) protruding above the soil. Permanent grass plots consisted of a mixture of ryegrass (*Lolium perenne*), timothy (*Phleum pratense*) and huia white clover (*Trifolium repens*). Both grass plots were maintained following UK Ministry of Agriculture regulations, which included grass cuts and leaving the cuttings on the plots.

Prior to observations, the bare (control) and treated plots were rotavated to ~0.2 m (0.66 ft) depth and treated with 'RoundUp' (isopropylamine salt of N-phosphonomethyl glycine) herbicide to remove vegetation. Then, mats were cut very carefully, if required, at one end and placed over the soil surface and attached with metal pegs. In these plots, some mats were cut from one end very carefully. Runoff volume and sediment yield were measured from 03/25/02-05/10/04 (total precipitation = 1319.8 mm). Runoff and soil erosion were collected from each plot in a concrete gutter, leading to a 0.02 m^3 (20 liters) capacity receptacle placed inside a 0.14 m^3 (140 liters) capacity container. The sediment collected in the tray gutters and in the concrete outlets of the central runoff plots was included by brushing it into the collecting systems prior to each measurement, as it had been eroded from the plots. Runoff was measured to the nearest ml, while sediment yield was measured by weighing containers, oven-drying the runoff overnight at 40^{o}C, and then reweighing the containers. This was performed regularly, usually every two weeks or after a substantial storm.

To further validate the results, another set of runoff experiments have been in progress at Hilton, with an additional treatment (10 m long plots with 1 m Buriti-mat buffer zones) compared with the earlier experiment (Figure 1b). Based on analysis of soil samples (0-0.05 m; 0-0.164 ft) collected in January, mean (n = 100) soil had a pH of 5.32 (± 0.17), SOM of 3.64% (± 0.66%), sand 0.524 kg kg^{-1}, silt 0.439 kg kg^{-1} and clay 0.037 kg kg^{-1}. The plots were bordered with wooden planks, with 0.1 m (~0.33 ft) intruding into the soil and 0.1 m (~0.33 ft) protruding above the soil. The pictures of a Borassus completely-covered plot (Plate 5) and a Buriti buffer strip plot (Plate 6) just after installation of the mats on 8 January 2007 are shown below. Runoff volume and sediment yield were measured after each substantial storm from 01/08/07-01/14/08 (total precipitation = 923.4 mm).

Plate 5. A completely covered plot (by Borassus mats) at Hilton, just after installation .

Plate 6. A Buriti buffer strip plot at Hilton.

2.4 Analyses of Selected Mat Properties

Physical properties of mats (size, thickness, mesh size, mass per unit area and percentage open area) were analysed in the laboratory taking six randomly selected samples of Borassus and Buriti mats. Mean moisture sorption depth was determined as outlined by Sutherland (1998), based on 10 randomly selected samples with dimensions of 0.15 x 0.15 m (0.49 x 0.49 ft).

2.5 Computation of Effectiveness of Geotextile-covered Plots

The splash erosion reduction effectiveness (SpERE) of Borassus mats in reducing splash output was determined using the equation:

$$\text{SpERE} = 100 \times \frac{[\text{Total bare}_{sp}\ (\text{kg m}^{-2};\ \text{lb ft}^{-2}) - \text{Total geotextile}_{sp}\ (\text{kg m}^{-2};\ \text{lb ft}^{-2})]}{\text{Total bare}_{sp}\ (\text{kg m}^{-2};\ \text{lb ft}^{-2})} \qquad [2]$$

where, Total bare_{sp} represents the total splash output measurements, and Total geotextile_{sp} represents the total splash output measurements for each of the individually tested geotextiles during the study period.

(a)

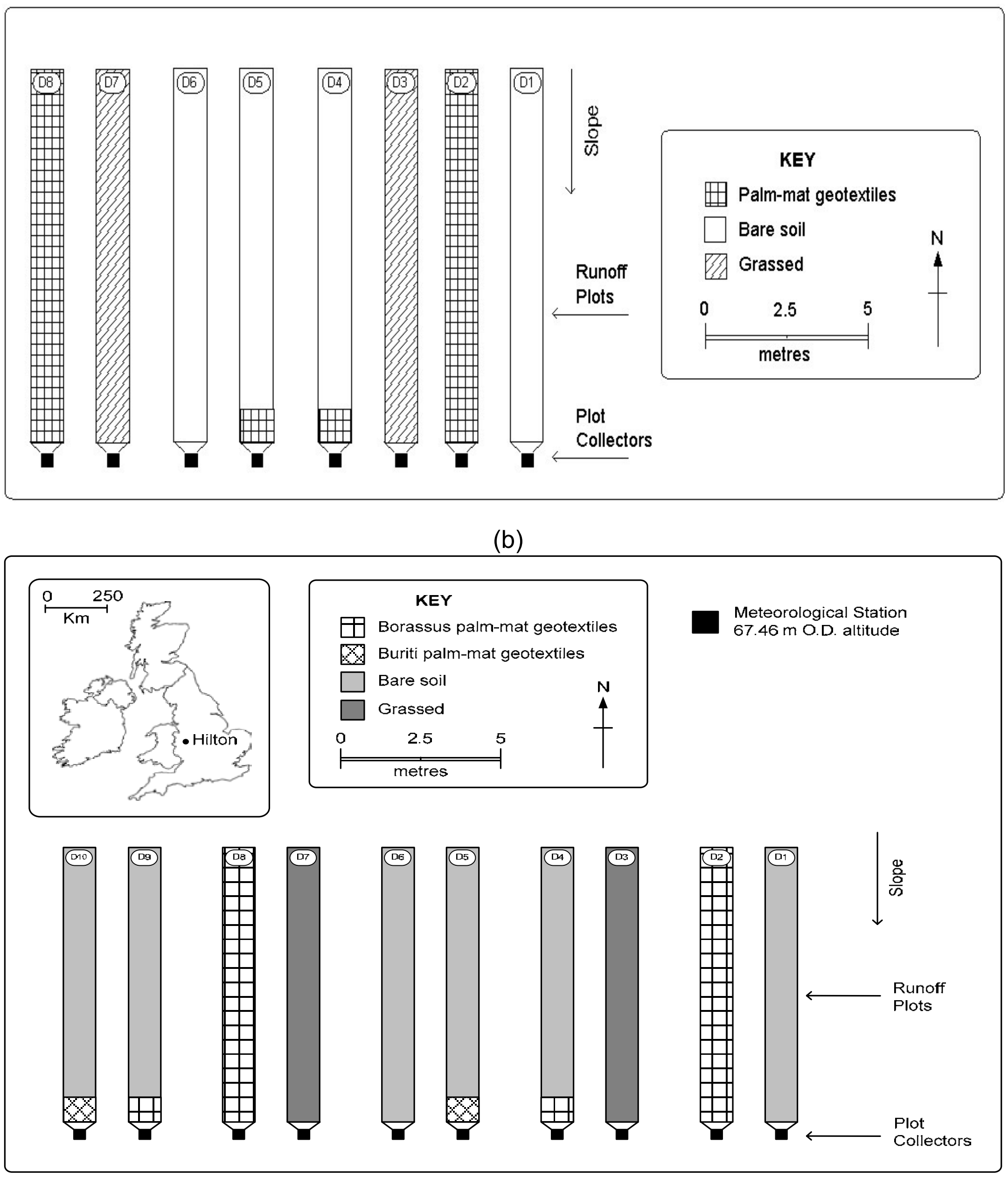

Figure 1. Schematic plan of the runoff plots at Hilton: (a) during 03/25/02-05/10/04 (b) during 01/08/07-01/14/08.

Sediment yield reduction effectiveness (SYRE) and runoff reduction effectiveness (RRE) were calculated following Sutherland (1998):

$$\text{SYRE (\%)} = 100 \times \frac{[\text{Bare sediment yield (kg m}^{-2}\text{; lb ft}^{-2}) - \text{Geotextile cover sediment yield (kg m}^{-2}\text{; lb ft}^{-2})]}{\text{Bare sediment yield (kg m}^{-2}\text{; lb ft}^{-2})} \quad [3]$$

$$\text{ROC (\%)} = 100 \times \frac{\text{Volume of runoff (m}^3\text{; liters)}}{\text{Volume of rainfall (m}^3\text{; liters)}} \quad [4]$$

where ROC represents runoff coefficient.

$$\text{RRE} = 100 \times \frac{[\text{Bare ROC (\%)} - \text{Geotextile cover ROC (\%)}]}{\text{Bare ROC (\%)}} \quad [5]$$

2.5 Statistical Analysis

Anderson-Darling's normality test was carried out to observe the normality of splash height and soil splash erosion data for both bare and covered plots and runoff and sediment yield data for all treatments. On the basis of that, t-tests were employed for splash height data and Mann-Whitney tests for splash erosion, runoff and sediment yield data to study differential responses to erosive processes. Mean and coefficient of variation (CV) were determined for runoff and soil loss data.

3. RESULTS

3.1 Selected Physical Properties of the Mats

Results show that Borassus mats have higher thickness, mass per unit area, size, moisture sorption depth (MSD) and cover percentage than Buriti mats (Table 1).

Table 1. Selected salient properties of the Borassus and Buriti mats

Properties	Borassus mats	Buriti mats
Material	Strips of palm leaves	Fibres of palm leaves
Mat size (mm x mm)	595 x 590 (±13.4 x 10.5)	509 x 507 (±10.7 x 9.8)
Mat thickness (mm)	20 (± 5)	10 (± 1)
Strip thickness (mm)	22.5 (± 5)	12.5 (± 2.5)
Mass per unit area (kg m^{-2})	1.091 (± 0.133)	0.413 (± 0.077)
Mass per unit area (lb ft^{-2})	0.223 (± 0.027)	0.085 (0.016)
Open area (%)	22.9 (± 3.3)	55.8 (± 5)
Aperture opening size (mm^2)	663.1 (± 99.9)	1442.8 (± 150.2)
Aperture width along with edge strip (mm)	29.1 (± 2.1)	38.4 (± 2.1)
Mesh size (mm x mm)	40 x 40 (± 2.5 x 2.5)	50 x 50 (± 2.0 x 2.0)
Characteristics	Stiff, semi-deformable	Flexible, deformable
Moisture sorption depth (mm)	0.28 (± 0.07)	0.22 (± 0.03)

Notes: Data in parentheses indicate Std. Dev. (n = 6 Borassus mats constructed in The Gambia and n = 6 Buriti mats constructed in Brazil).

3.2 Splash Erosion

The results (03/25/02-05/10/04) showed that covered plots had ~50% less total splash erosion than bare plots (9.64 kg m^{-2}; 1.97 lb ft^{-2}) (Table 2). Comparatively, mean splash height from Borassus mat-covered plots (0.141 m; 0.46 ft) was significantly (P < 0.05) less than the bare plots, by ~31% (Table 2). The results of the following experiment (01/08/07-01/14/08) also showed that covering the bare plots with Borassus mats significantly (P < 0.05) decreased both splash erosion and splash height (Table 2). The splash erosion reduction effectiveness (SpERE; calculated from Eq. 2) for the plots with Borassus mats was ~90%. Mean splash height of the covered plots with Borassus mats was also ~51% less than the bare plots (0.27 m; 0.89 ft) (Table 2).

Table 2. Effectiveness of Borassus mats on soil splash erosion for the plots at the Hilton Experimental Site during 06/10/02-02/09/04 (total precipitation = 1038.3 mm) and 22/01/07-21/01/08 (total precipitation = 919.2 mm).

Parameters	During 06/10/02-02/09/04				During 22/01/07-21/01/08			
	Splash erosion ($kg\ m^{-2}$)		Splash height (m)		Splash erosion ($kg\ m^{-2}$)		Splash height (m)	
	Bare n = 18	Mat-covered n = 18	Bare n = 14	Mat-covered n = 14	Bare n = 22	Mat-covered n = 22	Bare n = 21	Mat-covered n = 21
Total	9.64 (1.97)	4.82 (0.99)	-	-	24.81 (5.08)	2.59 (0.53)	-	-
Mean (of sets of measurements)	0.54 (0.11)	0.27 (0.06)	0.21 [0.69]	0.14 [0.46]	1.13 (0.23)	0.12 (0.02)	0.27 [0.89]	0.13 [0.43]
Std. Dev.	0.64 (0.13)	0.35 (0.07)	0.092 [0.30]	0.024 [0.08]	2.23 (0.46)	0.29 (0.06)	0.079 [0.26]	0.085 [0.28]
Appropriate test Statistics (Bare v covered)	Not significant (P = 0.062)		Significant (P < 0.05)		Significant (P < 0.05)		Significant (P < 0.001)	

Notes: Data in '()' indicate splash erosion ($lb\ ft^{-2}$); Data in '[ ]' indicate splash height [ft].

3.3 Runoff Volume

Results of the first set of experiments (03/25/02-05/10/04) show that total runoff from the Borassus buffer zone plots (0.0023 $m^3\ m^{-2}$; 2.3 liters m^{-2}) was ~37% less than the Borassus completely-covered plots (Table 3). Application of Borassus mats as total cover on bare soil increased runoff by ~24% over bare soil. However, that increase was not significant (P < 0.05). The runoff coefficient (ROC) for bare plots (0.27%) was significantly (P < 0.05) less than the permanent grassed plots, and that for Borassus completely-covered plots (0.34) was higher than grassed plots (Table 3). Results of the second set of experiments (01/08/07-01/14/08) imply that the bare soil generated most runoff (~0.0238 $m^3\ m^{-2}$; 23.8 liters m^{-2}) and permanent grassed plots least (Table 4). Borassus buffer strip plots had significantly less RRE than permanent grassed plots. Borassus completely-covered plots, Borassus buffer strip plots and Buriti buffer strip plots had similar runoff volumes.

3.4 Sediment Yield

Results of the first set of experiments indicate that total sediment yield in the Borassus completely-covered plots was ~64% less than bare plots (~0.09 kg m^{-2}; 0.02 lb ft^{-2}) (Table 3). Mean total soil loss equates to ~0.01, 0.04 and 0.03 kg m^{-2} from the permanent grassed plots, buffer zone (of Borassus mats) plots and completely-covered (by Borassus mats) plots, respectively. Total soil loss from the Borassus completely-covered plots was similar to the Borassus buffer zone plots. Results of the second set of experiments (2007-2008) reveal that all treatments significantly (P < 0.05) decreased total sediment yield from bare plots (~2.32 kg m^{-2}; 0.48 lb ft^{-2}) (Table 4). Borassus and Buriti mats as 1 m buffer strips on bare soil reduced soil erosion by ~93 and 98%, respectively (Table 4). Again, soil loss in the plots under Borassus completely-covered plots was similar to the buffer strip plots of the same mats. Thus, the first hypothesis that buffer strips of Borassus mats would be as effective as complete cover of the same mats was true for both sets of experiments. However, the second hypothesis that Borassus buffer strip plots would be more effective than Buriti buffer strip plots was not true, as observed during 2007-08. Although application of Buriti mats as buffer strips on bare soil was very effective to control soil loss and had similar sediment yield to all other treatments, the functional longevity of these mats at Hilton was ~1 year against ~2 years for Borassus mats. Thus, Buriti mats are not suitable for their reuse for > 2 seasons.

Table 3. Mean runoff and soil erosion rates for the plots at the Hilton Experimental Site during 03/25/02-05/10/04 (n = 30 sets of measurements; total precipitation = 1319.8 mm = 52 inches).

Parameters	Bare	Borassus buffer strip	Borassus completely-cover	Permanent grass
Total runoff (m^3 m^{-2})	0.0036 (78)	0.0023 (103)	0.0044 (90)	0.0028 (110)
Total runoff (liters m^{-2})	36	23	44	28
Total sediment yield (kg m^{-2})	0.09 (116)	0.037 (135)	0.031 (93)	0.013 (69)
Total sediment yield (lb ft^{-2})	0.018	0.008	0.006	0.003
ROC (%)	0.27	0.17	0.34	0.21
RRE (%)	-	37.0	-25.9	22.2
SYRE (%)	-	56.6	63.6	85.6

Notes: Data in parentheses indicate CV (%). ROC, RRE and SYRE indicate runoff coefficient, runoff reduction effectiveness and sediment yield reduction effectiveness, respectively.

Test Statistics (P values) for runoff volume: Bare v permanent grass < 0.05; Premanent grass v Borassus completely-covered < 0.001; Borassus completely-cover v Borassus buffer strip plots < 0.05; other comparisons are not significant (P > 0.05).

Test Statistics (P values) for soil loss: Bare v Borassus completely-cover < 0.01; Bare v permanent grass < 0.001; Bare v Borassus buffer strip < 0.01; Borassus completely-cover v permanent grass < 0.01; other comparisons are not significant (P > 0.05).

Table 4. Runoff and soil erosion rates for the plots at the Hilton Experimental Site during 01/08/07-01/14/08 (n = 29 sets of measurements; total precipitation = 923.4 mm = 36.4 inches).

Parameters	Bare	Borassus buffer strip	Borassus completely-cover	Buriti buffer strip	Permanent grass
Total runoff (m^3 m^{-2})	0.0238 (267)	0.0041 (112)	0.0063 (123)	0.0089 (297)	0.0031 (164)
Total runoff (liters m^{-2})	23.8	4.1	6.3	8.9	3.1
Total sediment yield (kg m^{-2})	2.32 (476)	0.16 (472)	0.03 (166)	0.04 (221)	0.02 (127)
Total sediment yield (lb ft^{-2})	0.475	0.033	0.006	0.008	0.004
ROC (%)	2.58	0.44	0.68	0.96	0.34
RRE (%)	-	82.9	73.6	62.8	86.8
SYRE (%)	-	92.9	98.6	98.2	99.1

Notes: Data in parentheses indicate CV (%). ROC, RRE and SYRE indicate runoff coefficient, runoff reduction effectiveness and sediment yield reduction effectiveness, respectively.

Test Statistics (P values) for runoff volume: Bare v permanent grass < 0.01; Borassus completely-cover v permanent grass < 0.01; Borassus buffer strip v permanent grass < 0.05; other comparisons are not significant (P > 0.05).

Test Statistics (P values) for soil loss: Bare v permanent grass < 0.001; Bare v Borassus completely-cover < 0.001; Bare v Borassus buffer strip < 0.001; Bare v Buriti buffer strip < 0.001; other comparisons are not significant (P > 0.05).

4. DISCUSSION

4.1 Splash Erosion

Results indicate Borassus mats are highly effective in reducing splash erosion. The lower splash height and amount of splashed soil for the covered plots reiterates the importance of retaining protective cover on sloping land, as geotextiles serve as protective barriers that dissipate raindrop kinetic energy. Following intense rainfall, fine sediment was visible, trapped by the palm-mats, resulting in decreased splash erosion (Mitchell et al., 2003). Geotextiles may also improve soil organic matter (SOM) and, thus, improve topsoil structure and aggregate stability, thereby decreasing splash erosion. Experimental results reported by Ziegler et al. (1997) showed that SpERE (calculated after 1 h of rainfall simulation study) for several geotextiles (C125, SC 150 BN and P 300) was > 97% compared to only 50% observed in this study (during 2002-04) and ~90% during 2007-08. Despite duration and intensity of rain event and inherent soil properties, total amount of rainsplash erosion from soils covered with different geotextiles depends on individual product properties (Rickson, 2006). Lower SpERE of Borassus mats than the above-mentioned geotextiles was probably due to less cover percentage of Borassus mats (~77% v ~86, 91 and 93% of SC 150BN, P 300 and C125, respectively). However, Ziegler et al. (1997) observed SpERE of PEC-MAT, having only 56% cover percentage, was as high as ~89%. Thus, apart from cover percentage, the ability of the geotextiles to control rainsplash erosion is affected by several other geotextile properties, such as moisture sorption depth, thickness and roughness (Zeigler et al., 1997).

4.2 Runoff Volume

Since biological geotextiles behave like mulching materials in reducing runoff depths (Smets et al., 2007), it can be expected that plots covered with palm-mat geotextiles would have lower runoff depths. Except for small runoff events under Borassus completely-covered plots during 2002-04, runoff depths were reduced in all covered plots by palm-mat geotextiles compared to bare soil. The presence of geotextile mats on slopes affects surface erosion in several ways: (i) surface runoff is divided into several smaller paths, due to the numerous obstructions caused by the presence of matting, thus, decreasing the overall damaging impact of flowing water; (ii) the net of geotextiles increased infiltration with their saturation and reduced flow of water by creating a network of small microdams, which further increased infiltration. Other studies conducted on runoff and erosion control support these findings (Langford and Coleman, 1996; Sutherland and Ziegler, 1996). Sutherland and Ziegler (2007) reported coir geotextiles significantly ($P < 0.05$) delayed the time to runoff generation and increased infiltration compared to the bare treatment. However, along with surface cover, slope gradient and rainfall intensity play major roles in determining infiltration rates (Poesen, 1984). In a laboratory study, Smets et al. (2007) found Borassus and Buriti mats were more effective in reducing runoff coefficients on a medium (15%) slope than that on a steep (45%) slope, ranging from ~76 to ~18%; (iii) in addition, the surface cover of geotextiles provided surface roughness that retarded overland flow velocities. For example, Sutherland and Ziegler (2007) found coir-geotextiles significantly ($P < 0.05$) decreased the leading edge flow velocities by ~33% compared to the bare treatment (9.6 cm s^{-1}); (iv) furthermore, the application of geotextiles alters the shear stress partitioning of overland flow (Thompson, 2001; Léonard and Richard, 2004).

During 2002-04, plots under Borassus completely-covered plots had ~24% higher (although statistically similar) runoff than bare soil. Low RRE in the Borassus completely-covered plots compared with the bare plots was probably due to low precipitation amounts (< 50 mm $week^{-1}$). When rainfall intensity was low, the percent of raindrops rolling over the mats and discharging as runoff without direct contact with soil might be higher than that under intense rain. Interestingly, Borassus buffer strip plots had ~36 and 48% less runoff than bare and Borassus completely-covered plots, respectively, during that period. The reason for the effectiveness of buffer zone plots in reducing runoff is not obvious at present, except the buffer zone acts as a barrier at the lower end of the slope and perhaps helps to maintain a thin layer of water against the slope, promoting higher infiltration.

4.3 Sediment Yield

The effectiveness of geotextiles in decreasing soil erosion mainly depends upon several properties, such as percent open area, mass per unit area, thickness, tensile strength, mass of geotextiles per unit area when they are wet, design and drapability (Ogbobe et al., 1998; Rickson, 2006; Sutherland and Ziegler, 2007). As geotextiles become wet they expand to the soil surface, enhancing drapability (adherence to surface microtopography) and, hence, erosion control (Sutherland and Ziegler, 1996). Furthermore, besides offering protection, geotextiles might improve SOM content, which binds soil particles and improves topsoil structure and aggregate stability, thereby reducing soil erosion, by encouraging infiltration. UK field experiments, comparing the effectiveness of different treatments in controlling sediment yield, revealed jute-net had only 1.4% of the sediment yield from bare plots, while jute-mat had 1.1% (Mitchell et al., 2003). In the first set of experiments, erosion rates of ~0.1-0.5 Mg ha^{-1} yr^{-1} were much less than the 1-2 Mg ha^{-1} yr^{-1} considered tolerable on British arable soils (Morgan, 1986). The low rates even on bare plots were mainly due to low precipitation intensities (mostly < 50 mm $week^{-1}$) during 2002-04.

The low sediment yield of the grassed plots confirms the importance of retaining protective vegetative cover on sloping land. This is because grass swards serve as protective barriers against rainfall kinetic energy, offer a source of organic matter to bind soil particles and grass roots aid the retention of topsoil structure. This study highlights the ability of palm-mat geotextiles, such as Borassus and Buriti mats, to significantly ($P < 0.05$) reduce erosion on agricultural soils. The results also showed that buffer strips of Borassus mats significantly ($P < 0.05$) reduced soil loss compared with bare soil and are as effective as complete cover of the same mats. Despite physical protection and sediment entrapment, buffer zones of Borassus mats may alter flow direction, thus creating several cross-drains. It is expected that buffer strips at the lower end of the plots would reduce flow speeds, which would eventually lead to sediment deposition within the small micro-dams. Wet networks of mats may then bind recently deposited sediment, thus effectively conserving soil on site. Vegetative buffer strips to trap sediments are an integral part of management practice in the UK. For example, in a study of vegetative buffer strips used in UK agriculture, surface runoff was reduced by a factor of six and soil loss was effectively eliminated (Jones, 1993).

Several researchers have reported that geotextiles were effective in reducing soil erosion compared to bare soil surfaces (Sutherland and Ziegler, 1996; Langford and Coleman, 1996; Mitchell et al., 2003). In laboratory studies, Sutherland and Ziegler (2007) found that between the two open weave coir geotextiles, the most effective geotextiles had a higher mass per unit area and less space between the regularly aligned grids of fibers. Although Borassus mats have higher mass per unit area than Buriti mats, SYRE values of Borassus and Buriti buffer zone plots were similar. The higher drapability (adherence to surface micro-topography) might have offset some of the physical disadvantages of Buriti mats (such as less mass per unit area and thickness and more percent open area) over Borassus mats. It was also observed that the effectiveness of palm-mat geotextiles decreased after six months of field study (during 2007-08) from ~99 to 90%. Like us, Lekha (2004) observed the effectiveness afforded by coir geotextiles in Kerala (India) was reduced from 99.6% during the pre-monsoon season to 78.1% in the post-monsoon season on a 26^{o} (48.8%) slope. Nevertheless, a ~90% SYRE at Hilton is a clear indication that the technology is extremely efficient in minimizing erosion on this loamy sand soil.

Smets et al. (2007) observed that both Borassus and Buriti mats significantly ($P < 0.05$) decreased inter-rill soil loss compared with bare soil on 15 and 45% slopes during 45 and 67 mm h^{-1} rainfall intensities. Thus, these mats have tremendous potential for non-agricultural use. Apart from utilization of these mats in highways, river banks, stabilization of ponds, and the preservation of archaeological sites the mats could be used as partial cover on certain high risk crops (such as potatoes) in some pockets of land with high erosion risk, on certain high value crops (such as sugar beet) and to cover bare soil once the main crop is harvested. As the functional longevity of Borassus mats is ~2 years, they can possibly be reused for 3-4 seasons (to cover the bare soil once the main crop is harvested) and upon degradation the mats would probably improve soil quality. In the UK, mean annual soil loss in the plots under maize, potatoes, sugar beet and potato based cropping system was estimated to be ~5.3 Mg ha^{-1} (Morgan, 1985), 2.5 m^3 ha^{-1}, 3.0 m^3 ha^{-1} (Boardman and Evans, 2006) and ~4.3 Mg ha^{-1} (Morgan and Finney, 1982), respectively. The estimated mean soil loss to produce maize and soybean in a rotation in the USA was ~5.3 Mg ha^{-1} yr^{-1} (O'Neal et al., 2005). Thus, erosion rates on British arable soils can exceed tolerable levels and it is possible that use of biogeotextiles could significantly ($P < 0.05$) decrease erosion rates. Pimentel et al. (1995) estimated total on-site and off-site costs of ~$196 ha^{-1} for soil loss by water and wind at 17 Mg ha^{-1} yr^{-1} in the USA. That estimated cost was exclusive of loss of water as runoff, soil biota and biodiversity, SOM, secondary and micro-nutrients, soil physical properties and crop yield. Thus, at ~$0.40 per square metre (~$4000 ha^{-1}), covering agricultural soil completely with palm-mat geotextiles may be economically viable if the mats could be recycled and used as buffer strips. At Hilton, Borassus Buffer strip plots during the experimental year saved ~21.6 Mg soil loss ha^{-1}. Assuming all other factors are similar to the study of Pimentel et al. (1995), these plots would have saved $250 ha^{-1} (based on 1995 estimates), as against $400 ha^{-1} as production costs (material and labour costs) of these mats (based on

2005 estimates). Apart from the environmental benefits of using mats as buffer strips, the other advantageous facts are that the mats would last for 2 years. Furthermore, in the broader sense, the economic costs of producing these mats would go from a group of farmers/individuals to socially disadvantageous groups.

5.0 CONCLUSIONS

This work forms one of the pioneering research attempts on the application of palm-mat geotextiles (Borassus and Buriti mats) for the control of soil erosion on problematic slopes under the umbrella of the BORASSUS Project (http://www.borassus-project.net). The results of both sets of studies indicate that application of Borassus mats on bare soil significantly ($P < 0.05$) reduced rainsplash erosion during both 2002-04 and 2007-08. Borassus mats as 1 m (~3.28 ft) protective buffer strips on bare soil (10 m; ~32.8 ft long) significantly ($P < 0.05$) reduced soil erosion (by ~57% during 2002-04 and by ~93% during 2007-08). Sediment yield reduction in the Borassus completely-covered plots was similar to the buffer zone plots of the same mats during both experimental periods. However, the runoff reduction of the completely-covered plots was significantly ($P < 0.05$) less than that of the Borassus buffer zone plots during 2002-04. Although results during 2007-08 show buffer strip plots of Borassus and Buriti mats had similar effects in reducing total runoff and soil loss, functional longevity of Buriti mats was ~1 year against ~2 years of Borassus mats at Hilton. Thus, the use of Borassus mats as buffer strips on bare plots is highly effective for soil and water conservation on loamy sand soils in the UK. It is, therefore, proposed that the ratio of buffer strip to the total length of the plot (1:10 in these studies of Hilton) under different agro-environmental conditions needs to be evaluated.

ACKNOWLEDGEMENT

All authors acknowledge and thank the European Commission for the financial support awarded to the BORASSUS Project (Contact number: INCO-CT-2005-510745).

REFERENCES

Boardman, J. 1998. “Public policy and soil erosion in Britain.” In *Hooke, J.M. (ed.), Geomorphology in Environmental Planning,* John Wiley & Sons, Chichester. 33-50 pp.

Boardman, J., and D.T. Favis-Mortlock. 1993. “Climate change and soil erosion in Britain.” *The Geographical Journal* 159: 179-183.

Boardman, J., and R. Evans. 2006. “Britain.” In *Boardman, J., and Poesen, J., (eds.), Soil Erosion in Europe,* John Wiley & Sons, Chichester, 439-453 pp.

Davies, K. 2000. “An evaluation of the effectiveness of palm-mat geotextiles on the conservation of loamy soils of the Bridgnorth series.” *Unpublished B.Sc. dissertation,* The University of Wolverhampton, U.K., 18-20 pp.

Davies, K., M.A. Fullen, and C.A. Booth. 2006. “A pilot project on the potential contribution of palm-mat geotextiles to soil conservation.” *Earth Surface Processes and Landforms* 31: 561-569.

Fullen, M.A., and A.H. Reed 1986. “Rainfall, runoff and erosion on bare arable soils in East Shropshire, England.” *Earth Surface Processes and Landforms* 11: 413-425.

Hann, M.J., and R.P.C. Morgan. 2006. “Evaluating erosion control measures for biorestoration between the time of soil reinstatement and vegetation establishment.” *Earth Surface Processes and Landforms* 31: 589-597.

Hollis, J.M., and A.H. Reed. 1981. “The Pleistocene deposits of the southern Worfe Catchment.” *Proceedings of the Geological Association* 92: 59-74.

Ingold, T.S. 1996. “Market study.” In *CFC/IJO, Technical specification and market study of potentially important jute geotextiles.* Project Completion Report by Silsoe College, Cranfield University (Project Executing Agency).

Jones, R.L. 1993. “Role of field studies in assessing the environmental behaviour of herbicides.” In *Proc., pp. 1275-1282; Brighton Crop Protection Conference-Weeds 9B-1*, Brighton, U.K.

Langford, R.L., and M.J. Coleman. 1996. “Biodegradable erosion control blankets prove effective on Iowa wildlife refuge.” In *Proc., pp. 13-20; 27th International Erosion Control Association Conference,* Seattle, USA.

Léonard, J., and G. Richard. 2004. “Estimation of runoff critical shear stress for soil erosion from soil shear strength.” *Catena* 57: 233–249.
Lekha, K.R. 2004. “Field instrumentation and monitoring of soil erosion in coir geotextile stabilized slopes-A case study.” *Geotextiles and Geomembranes* 22: 399-413.
Mitchell, D.J., A.P. Barton, M.A. Fullen, T.J. Hocking, Wu Bo Zhi, and Zheng Yi. 2003. “Field studies of the effects of jute geotextiles on runoff and erosion in Shropshire, U.K.” *Soil Use and Management* 19: 182-184.
Morgan, R.P.C. 1985. “Soil erosion measurement and soil conservation research in cultivated areas of the U.K.” *The Geographical Journal* 151: 11-20.
Morgan, R.P.C. 1986. “Soil degradation and soil erosion in the loamy belt of northern Europe.” In *Chisci, G., and Morgan, R.P.C. (eds.), Soil Erosion in the European Community: Impact of Changing Agriculture,* A.A. Balkema, Rotterdam. 165-172 pp.
Morgan, R.P.C. 2005. Soil erosion and conservation (2nd ed.), Wiley, New York. 198 pp.
Morgan, R.P.C., and H.J. Finney. 1982. “Stability of agricultural ecosystems: validation of a simple model for soil erosion assessment.” *International Institute for Applied Systems Analysis*, Collaborative Paper No. CP-82-76.
Nanko, K., S. Mizugaki, and Y. Onda. 2008. “Estimation of soil splash detachment rates on the forest floor of an unmanaged Japanese cypress plantation based on field measurements of throughfall drop sizes and velocities.” *Catena* 72: 348-361.
Ogbobe, O., K.S. Essien, and A. Adebayo. 1998. “A study of biodegradable geotextiles used for erosion control.” *Geosynthetics International* 5: 545-553.
O'Neal, M.R., M.A. Nearing, R.C. Vining, J. Southworth, and R.A. Pfeifer. 2005. “Climate change impacts on soil erosion in Midwest United States with changes in crop management.” *Catena* 61: 165-184.
Oosthuizen, D., and D. Kruger. 1994. “The use of Sisal fibre as natural geotextile to control erosion.” In *Proc.,* pp. 18-23; *Fifth International Conference on Geotextiles, Geomembranes and Related Products,* G.V. Rao, and K. Balan, (eds.), Coir geotextiles-Emerging Trends, Singapore.
Pimentel, D., C. Harvey, P. Resosudarmo, K. Sinclair, D. Kurz, M. McNair, M. Crist, L. Shpritz, L. Fitton, R. Saffouri, and R. Blair. 1995. “Environmental and economic costs of soil erosion and conservation benefits.” *Science* 267: 1117-1123.
Poesen, J. 1984. The influence of slope angle on infiltration rate and Hortonian overland flow.” *Zeitschrift für Geomorphologie*, Supplement Band, 49: 117-131.
Poesen, J., and D. Torri. 1988. “The effect of cup size on splash detachment and transport measurements. Part 1: Field measurements.” *Catena Supplement* 12: 113-126.
Rickson, R.J. 2006. “Controlling sediment at source: an evaluation of erosion control geotextiles.” *Earth Surface Processes and Landforms* 31: 550-560.
Savat, J., and J. Poesen. 1981. “Detachment and transportation of loose sediments by raindrop splash: Part I. The calculation of absolute data on detachability and transportability.” *Catena* 8: 1-17.
Smets, T., J. Poesen, M.A. Fullen, and C.A. Booth. 2007. Effectiveness of palm and simulated geotextiles in reducing run-off and inter-rill erosion on medium and steep slopes.” *Soil Use and Management* 23: 306-316.
Sutherland, R.A. 1998. “Rolled erosion control systems for hillslope surface protection: A critical review, synthesis and analysis of available data. I. Background and formative years.” *Land Degradation and Development* 9: 465-486.
Sutherland, R.A., and A.D. Ziegler. 1996. “Geotextile effectiveness in reducing interrill runoff and sediment flux.” In *Proc., pp. 359-370; 26th International Erosion Control Association Conference,* Atlanta, USA.
Sutherland, R.A., and A.D. Ziegler. 2007. “Effectiveness of coir-based rolled erosion control systems in reducing sediment transport from hillslopes.” *Applied Geography* 27: 150-164.
Thompson, A.M. 2001. “Shear stress partitioning for vegetation and erosion control blankets.” *Ph.D. Dissertation*, Department of Biosystems and Agricultural Engineering, University of Minnesota, St. Paul, Minnesota (UMI Number: 3032015).
van Dijk, A.I.J.M., A.G.C.A. Meesters, and L.A. Bruijnzeel. 2002. “Exponential distribution theory and the interpretation of splash detachment and transport experiments.” *Soil Science Society of America Journal* 66: 1466-1474.
Vishnudas, S., H.H.G. Savenije, P. van der Zaag, K.R. Anil, and K. Balan. 2006. “The protective and attractive covering of a vegetated embankment using coir geotextiles.” *Hydrology Earth System Sciences* 10: 565-574.
Ziegler, A.D., R.A. Sutherland, and L.T. Tran. 1997. “Influence of rolled erosion control systems on temporal rainsplash response-a laboratory rainfall simulation experiment.” *Land Degradation and Development* 8: 139-157.

PHOTOGRAPH OF AUTHORS

Ranjan Bhattacharyya

Michael A. Fullen

Colin A. Booth

ADDITIONAL PRESENTER

None

AUTHOR’S STATEMENT OF UNDERSTANDING

We have read the Author's Statement of Understanding.

MARKETING PARAGRAPH

Under temperate climatic conditions on a loamy sand soil, comparison of soil loss and runoff rates from replicated 10 m^2 field plots indicate buffer strips (area coverage ~10%) of palm-mat geotextiles (Borassus and Buriti mats) can effectively conserve soil and water, with results similar to plots completely-covered by Borassus mats.