The BORASSUS Project: aims, objectives and preliminary insights into the environmental and socio-economic contribution of biogeotextiles to sustainable development and soil conservation

C. A. Booth[1], M. A. Fullen[1], et al (see last page of paper)

Abstract

Field and laboratory studies suggest geotextile mats constructed from palm leaves are an effective, sustainable and economically viable soil conservation technique. The three-year (2005-08) EU-funded BORASSUS Project (Contract number INCO-CT-2005-510745) is evaluating their long-term effectiveness in controlling soil erosion and assessing their sustainability and economic viability in 10 countries in Africa, Europe, South America and South-East Asia. The technique offers potentially novel bioengineering solutions to environmental problems, including technologies for soil conservation, sustainable plant production and use of indigenous plants, improved ecosystem management, decreasing deforestation, improving agroforestry and cost-effective geotextile applications in diverse environments. Palm geotextiles may improve socio-economic foundations for sustainable development and the benefits for developing countries may include poverty alleviation, engagement of local people as stakeholders, employment for disadvantaged groups, small and medium enterprise (SME) development, earning hard currency, environmental education and local community involvement in land reclamation and environmental education programmes. These benefits are achieved through: (a) Promotion of sustainable and environmentally-friendly palm agriculture to discourage deforestation, promoting both reforestation and agroforestry; (b) Construction of palm geotextiles developing into a rural labour-intensive industry, particularly encouraging employment of socially-disadvantaged groups; and (c) Export of palm geotextiles to industrialized countries earns hard currency for rural developing economies, based on the principles of fair trade. In Europe, experiments are in progress in diverse field environments (agricultural and archaeological sites, coastal sand dunes and engineered slopes) and in laboratory simulations of both water and wind erosion processes.

Keywords: soil and water conservation, Bioengineering technology, socio-economic development.

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1 Introduction

Recent improvements have been made in soil conservation technology and over the last three decades significant advances have been made in our understanding of soil erosion mechanisms and rates under different environmental conditions. However, there have been few advances in developing innovative soil conservation techniques. Moreover, relatively little research has been conducted at the interface between soil technology and socio-economic issues, such as sustainable development, poverty alleviation and rural employment. One technique for soil conservation is geotextiles, which can create stable, non-eroding environments that provide the time necessary for vegetation to establish and grow. If constructed from indigenous materials, geotextiles can be effective, affordable and compatible with sustainable land management strategies.

Despite synthetic geotextiles dominating the commercial market, geotextiles constructed from organic materials are highly effective in erosion control and vegetation establishment. Furthermore, they usually have 100% biodegradability and better adherence to the soil. Moreover, in developing regions, commercially-marketed materials are usually too expensive. With this in mind, the BORASSUS Project is assessing the feasibility of employing palm-leaf geotextile mats as a potential soil conservation technique. This involves the promotion of sustainable and environmentally friendly palm-agriculture and offers a potentially profitable technique to augment the income of financially deprived farmers.

This article presents insights into the aims and objectives of the BORASSUS Project and some preliminary (first-year) findings into the: (i) Manufacture and socio-economic rewards of geotextiles; (ii) Field applications of geotextiles; and (iii) Laboratory-based geotextile experiments.

2 The BORASSUS Project

While significant recent improvements have been made in soil conservation technology, relatively little research has been conducted at the interface between soil technology and socio-economic issues, such as sustainable development, poverty alleviation and rural employment. Over the last three decades, significant advances have been made in our understanding of various soil erosion mechanisms and rates under different environmental conditions. Despite this achievement, there have been few advances in developing innovative soil erosion control techniques. Palm-mat geotextiles have the potential to advance soil erosion control on, for instance, building and road construction sites and in coastal defence. However, available studies do not allow quantification of the effectiveness of palm-mat geotextiles in reducing rates of soil erosion by wind and water. Several work-packages in this Project address this issue through field measurements. However, a particular field site does not always offer the range of soil and slope conditions that can be found elsewhere in the region. One approach to establish the effectiveness of palm-mat geotextiles for such conditions is through controlled laboratory experiments, during which erosive processes (rainfall and runoff) are simulated for a range of representative soil and slope conditions in the absence of, and with, palm-mat geotextiles.

Palm-leaf geotextiles offer considerable potential to contribute to sustainable development and soil conservation. Geotextiles efficiently and economically conserve soil, especially in engineering and construction applications within the industrialized world. It is postulated that, in the humid tropics, their use will promote sustainable and environmentally-friendly palm-agriculture, labour-intensive employment and earn hard currency.

The European Commission is funding the BORASSUS Project (Contract number INCO-CT-2005-510745) for three-years (2005-08) to investigate 'The Environmental and Socio-economic Contribution of Palm Geotextiles to Sustainable Development and Soil Conservation'. In Project Year 1 the main focus has been establishing the infrastructure to successfully and efficiently carry out project objectives.

Project objectives are deliverable to both 'Developing countries' and 'Industrialized countries'. The BORASSUS Team are scientifically testing the following four hypotheses:

(1) Promotion of sustainable and environmentally-friendly palm agriculture will discourage deforestation and promote both reforestation and agroforestry. It will also offer a potentially profitable technique, which will provide financially-deprived farmers with supplementary income from palm geotextiles and thus contribute to poverty alleviation.

(2) Construction of palm geotextiles will develop into a rural based labour-intensive industry, particularly encouraging the employment of socially-disadvantaged groups, such as women, disabled and elderly people. This will in turn contribute to the stabilization of rural populations, thus decreasing migration to urban areas.

(3) Export of completed palm geotextiles to industrialized countries will earn hard currency for the developing economies and promote development, based on the principles of fair trade.

(4) Geotextiles efficiently and economically conserve soil. Palm geotextiles will be especially beneficial for complex engineering problems, particularly in the building and road construction industries and coastal defence. Temporary application of geotextiles will allow sufficient time for plant communities to stabilize engineered slopes.

The Project consists of 13 work-packages (WP) (Figure 1), using a team based in Europe (Belgium, Hungary, Lithuania and the U.K.), Africa (The Gambia and South Africa), South-East Asia (China, Thailand and Vietnam) and South America (Brazil). The work-packages are structured into three distinct pathways: (i) experimental field studies; (ii) laboratory and field studies; and (iii) socio-economic impacts and issues. Administrative and financial directions are centrally co-ordinated (WP 0), while information from all three-research strands is integrated into an information dissemination strategy (WP 12).

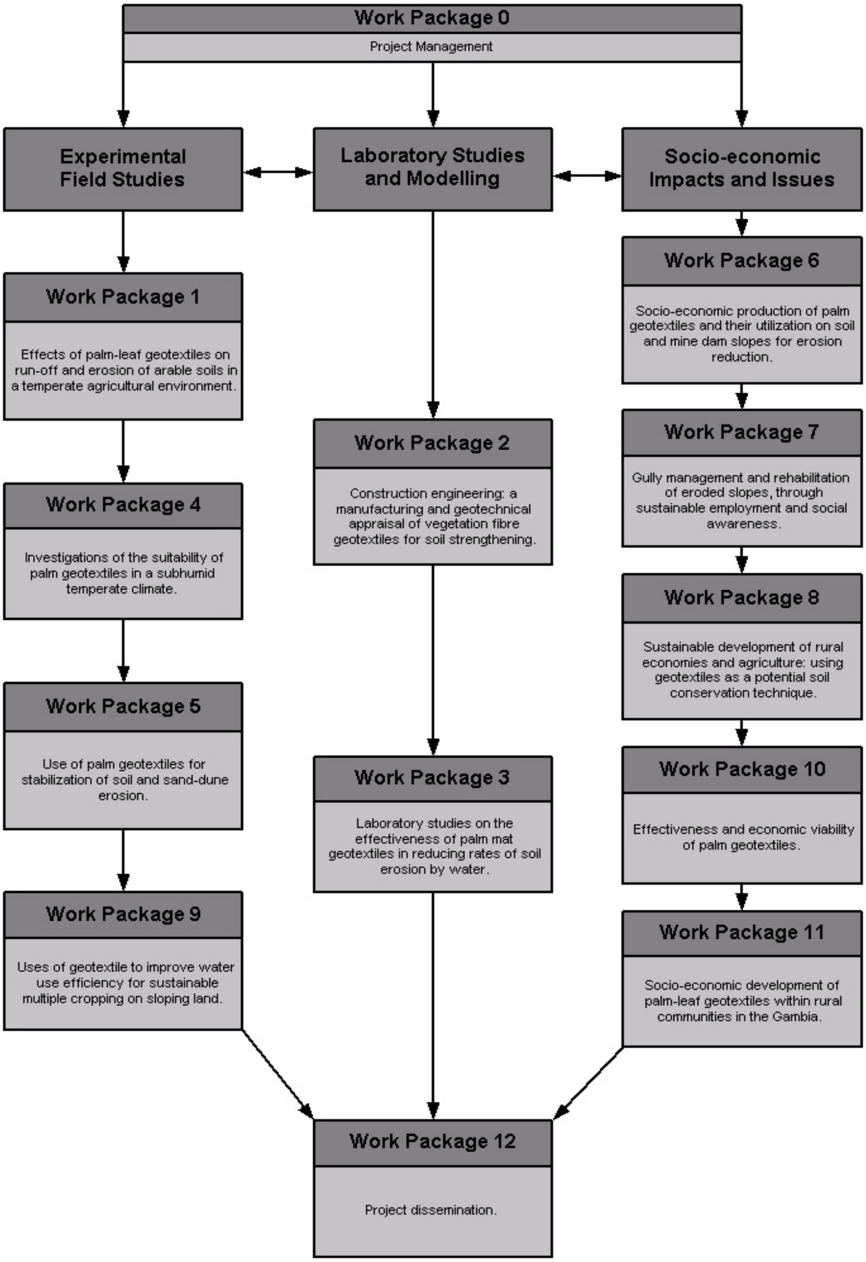

Figure 1: Work-package structure of the BORASSUS Project (WPs 0–12).

3 Preliminary (first-year) project insights

An initial pilot study (2002-03) has already been conducted on the potential of palm-leaf geotextile mats at the Hilton Experimental Site, Shropshire, UK [1,2]. Field studies show the mats decrease sediment yield compared with bare soil. Moreover, an initial 'time and motion' study (May 2001) was conducted in The Gambia (West Africa) during the construction of the mats, to assess the economic viability of utilizing the *Borassus aethiopum* leaf as a geotextile. Initial results were very favourable, showing the mats could be constructed at an economically-viable price, comparable to other geotextiles.

The following observations, from the first-year of the BORASSUS Project, build on the pilot-project and offer further insights into the global contribution of palm-mat geotextiles for soil conservation and sustainable development.

3.1 Manufacture and socio-economic rewards of geotextiles

Geotextile mats are constructed from the leaves of black rhun palm (*Borassus aethiopum*) and Buruti palm (*Mauritia flexuosa*) and comparable indigenous fibre resources (Figure 2) [1,3].

The genus Borassus is one of the most widely distributed of the Palmae, with a range extending from West Africa to eastern Indonesia. Literature on Borassus palms tends to be limited to botany. As Borassus palms are of significant value to local populations, attention has been drawn to them because of global assessments of the potential of underdeveloped tropical plant resources. If harvested correctly, Borassus palm is highly sustainable. Allowed to grow to maturity, they are estimated to have 100 years longevity and grow to 25-30 m height with some 30-40 palmate fronds. One leaf is produced per month and they naturally shed 12-14 fronds annually. Buruti are extensive Palmae resources in South America and could fulfil similar potential as Borassus.

Palm-leaf geotextiles can improve the socio-economic foundation for sustainable development in developing countries. Potential benefits include poverty alleviation, engagement of disadvantaged groups as stakeholders, employment for disadvantaged groups, SME development, export of geotextiles earning hard currency, environmental education and local community involvement in reclamation and environmental-improvement programmes. Education programmes are necessary to actively inform the public of the importance of soil as an essential resource. These schemes should particularly encourage 'land literacy' among participants so that society recognizes broader benefits of effective soil conservation, such as its potential contribution to habitat creation, biodiversity and carbon sequestration.

To harvest and manufacture the mats, the thick central spine, which gives the leaf its fan-like appearance, were stripped and the vegetation cut into lengths (~1.5 m length and 2 cm width). Using a 50 x 50 cm (2,500 cm^2) wooden template, the outer edge of the mat was sewn using leaf-fibre waste and the strips were woven into a grid pattern, vertically and horizontally, using a slipknot at 5-7 cm intervals. Then every strip was wrapped around, working from one edge to the other, using the prepared material.

Figure 2: (a)+(b) African Borassus palm-leaf geotextile mat production; (c)+(d) South American Buriti palm-leaf geotextile mat production; and (e)+(f) South-east Asia palm-leaf and Bamboo geotextile mat production.

3.2 Field application of geotextiles

Field experiments are focusing on soil erosion studies on natural and engineered slopes (UK, Lithuania, South Africa, Brazil) and various treatments on agricultural plots (Hungary, China, Thailand and Vietnam) (Figure 3). Erosion plot studies reveal palm-mat geotextiles are effective in reducing runoff (particularly used as a buffer zone) and also effective in reducing erosion compared to bare soil. Therefore, preliminary indications are that palm-leaf geotextile mats are very effective in conserving soil on sloping lands.

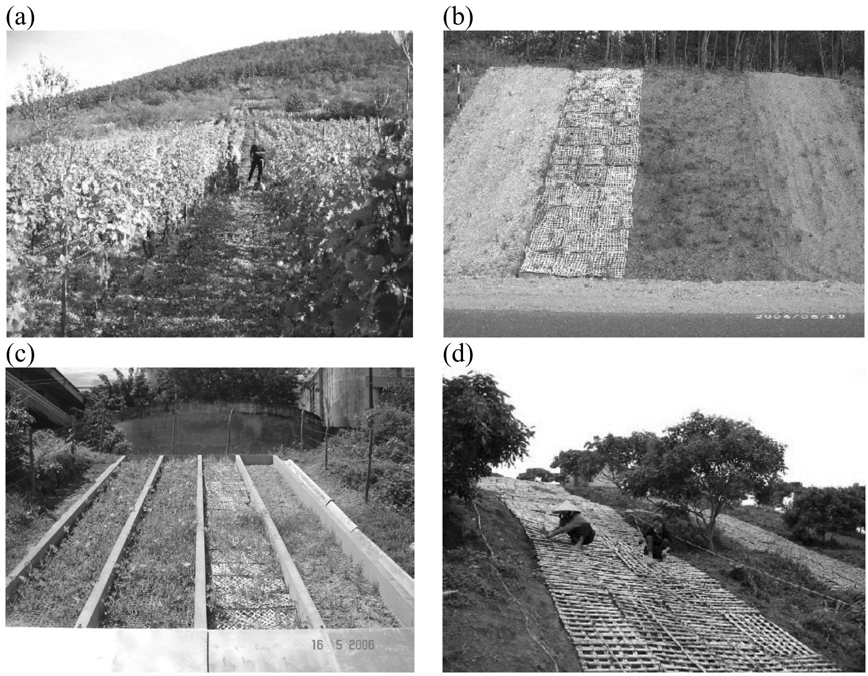

Figure 3: Experimental field sites: (a) Vineyard plots in Hungary; (b) Engineered roadside plots in Lithuania; (c) Erosion plots at São Luís, Brazil; and (d) Agricultural treatment plots, Tam Nong, Vietnam.

Agricultural field experiments using geotextiles mats, alongside other treatments for comparison, have been used as a soil and water conservation tool, whilst growing crops (soybean, peanuts, wheat, maize, rice, beans and tobacco) and fruit-trees (mango, lemon and Jujube) in SE Asia (China, Thailand and Vietnam). Results from several workpackages indicate that the application of geotextiles aids soil moisture conservation, decreases soil temperature, controls water erosion and promotes crop growth on sloping highlands.

3.3 Laboratory-based geotextile experiments

Laboratory experiments were conducted to investigate the effectiveness of two types of palm-mats (Borassus and Buriti) in increasing rain infiltration rates and reducing runoff generation and splash and interrill erosion rates (Figure 4). Furthermore, the effect of the mesh size of geotextiles on hydrological and erosion processes was investigated. In an interrill erosion plot geotextiles were placed on a sandy loam soil. During a simulated storm of 67 mm/h for 90 minutes, runoff and interrill soil loss were measured. Three slope gradients were simulated (i.e. 15, 30 and 45%). Results show Borassus mats are very effective in reducing interrill erosion rates (they reduce interrill erosion rates by

90% compared to a bare soil surface on a 15% slope), but are less effective in reducing runoff volumes (they reduce runoff volumes by 36% compared to a bare soil surface on a 15% slope). On the steeper slopes all the geotextiles are less effective in reducing interrill erosion rates and runoff volumes. The geotextiles with the smallest mesh sizes (1 x 1 cm) are the most effective in reducing interrill erosion rates and runoff volumes.

(a) (b)

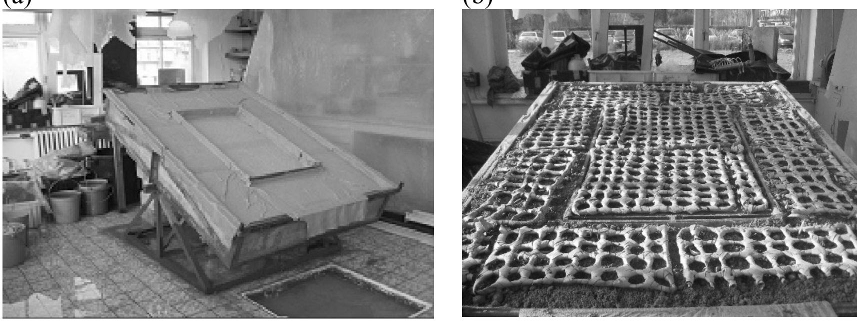

Figure 4: Interrill erosion flume: (a) Wet floor cloths over perforated plates and (b) Test area and buffer zone covered with palm-leaf mats on soil (Belgium).

4 Discussion

Preliminary project results are very positive; with direct field and laboratory evidence indicating biogeotextiles can significantly decrease water runoff and soil erosion [4]. Geotextile mats assist the conservation of soil water and decrease evaporation from the soil during dry periods. These effects appear reasonably consistent between climates (humid temperate within the EU States and within the humid to sub-humid climates of the tropical to sub-tropical INCO-DEV States). Furthermore, their effects appear consistent between selected land use systems (arable land, degraded gullied land, orchards and vineyards). These initial conclusions closely accord with preliminary results from laboratory simulations.

5 Ongoing research

The BORASSUS research team will continue to work towards the first complete scientific and socio-economic evaluation of the potential of palm-leaf geotextiles. Full geotechnical evaluations of these geotextiles are an integral part of the work. Therefore, as part of the established information dissemination strategy, the team will publish manufacturing and production protocols and standards. These will be broadly disseminated and available for SMEs to adopt and adapt. These standards will contribute to the global production of high-quality palm-mat geotextiles suitable for multiple and complex applications.

Further information can be obtained from the BORASSUS Project website (www.borassus-project.net). Project findings and publications will be progressively listed on this website.

6 Conclusions

Geotextiles constructed from indigenous tropical/subtropical leaves has potential as a biotechnical soil conservation method. The results from the first year of investigation indicate geotextiles constructed from palm-leaf effectively reduced soil erosion. If harvested correctly, these resources are highly sustainable and readily available in most humid and sub-humid bioclimatic regions. They are biodegradable, providing organic content matter to stabilize the soil and their permeability makes them suitable for use with cohesive soils. There are no high-energy production procedures in the manufacturing process and they may provide a cost-effective method of conserving soil in developing countries, where farming techniques are scaled to low levels of disposable income.

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