CORPUS PUBLISHERS

Environmental Sciences and Ecology: Current Research (ESECR)

ISSN: 2833-0811

Volume 7 Issue 3, 2026

Article Information

Received date : May 21, 2026

Published date: June 01, 2026

*Corresponding author

Holanda FSR, 1Universidade Federal de Sergipe, São Cristóvão - Sergipe, Brazil,

DOI: 10.54026/ESECR/10132

Keywords

Soil erosion; Nature Based Solutions;Soil and Water Conservation;Sustainability

Review article

Nature-Based Soil and Water Bioengineering in Tropical Environments: Natural Fiber Geotextiles, Root Reinforcement and Ecological Restoration

Francisco Sandro Rodrigues Holanda[1*], Luiz Diego Vidal Santos[2], Eliana Midori Sussuchi[1], Sandro Griza[1], Alceu Pedrotti[1], Renisson Neponuceno de Araujo Filho[3], Kairon Rocha Andrade[1], Arnon Sillas Novais Souza[1], Valdir Ribeiro Pimenta Neto[1], Ially Silva Santos[1], Emerson Guedes da Silva[1],Emerson Conceição de Jesus[1], Emanuel Menezes da Conceição[1], Laura Fonseca dos Santos[1], Marçal Rodrigues Marçal[1], Marlon Pedro Santos Gomes[1], Antonio Luiz Alves Pimenta Neto[1] Marcos Oliveira Santos[1], Alarico José da Silva Azerêdo[1], Henrique Antonio Silva[1].

[1]Universidade Federal de Sergipe, São Cristóvão - Sergipe, Brazil,
[2]Universidade Estadual de Feira de Santana, Feira de Santana - Bahia, Brazil,
[1]Universidade Federal de Sergipe , São Cristóvão - Sergipe, Brazil,
[1]Universidade Federal de Sergipe , São Cristóvão - Sergipe, Brazil,
[1]Universidade Federal de Sergipe , São Cristóvão - Sergipe, Brazil,
[3]Universidade Federal Rural do Pernambuco, Recife – Pernambuco, Brazil
[1]Universidade Federal de Sergipe, São Cristóvão – Sergipe, Brazil
[1]Universidade Federal de Sergipe, São Cristóvão – Sergipe, Brazil
[1]Universidade Federal de Sergipe, São Cristóvão Sergipe, Brazil,
[1]Universidade Federal de Sergipe , São Cristóvão Sergipe, Brazil,
[1]Universidade Federal de Sergipe, São Cristóvão - Sergipe, Brazil,
[1]Universidade Federal de Sergipe , São Cristóvão - Sergipe, Brazil1
[1]Universidade Federal de Sergipe , São Cristóvão - Sergipe, Brazil,
[1]Universidade Federal de Sergipe , São Cristóvão - Sergipe, Brazil,
[1]Universidade Federal de Sergipe , São Cristóvão - Sergipe, Brazil,
[1]Universidade Federal de Sergipe , São Cristóvão - Sergipe, Brazil,
[1]Universidade Federal de Sergipe, São Cristóvão - Sergipe, Brazil
[1]Universidade Federal de Sergipe , São Cristóvão - Sergipe, Brazil,
[1]Universidade Federal de Sergipe, São Cristóvão - Sergipe, Brazil,
[1]Universidade Federal de Sergipe, São Cristóvão - Sergipe, Brazil,

Abstract

This integrative review synthesizes the scientific and technological advances developed by the Laboratory of Erosion and Sedimentation in northeastern Brazil in the field of Soil and Water Bioengineering. The study consolidates experimental and applied research focused on biodegradable geotextiles manufactured from natural fibers, vegetation-based stabilization systems, root biomechanics, riverbank erosion control and ecological restoration in tropical environments. The review integrates findings from field experiments, geotechnical analyses, hydrosedimentological monitoring, tensile strength testing, scanning electron microscopy and digital image processing. Particular emphasis is given to native and tropical species such as Paspalum millegrana Schrad, Chrysopogon zizanioides (L.), Typha domingensis Pers, Eleocharis sp. R.Br and Syagrus coronata (Mart.) Becc and Jatropha curcas L., Cocos nucifera L., Ananas comosus (L.) Merr., Musa paradisiaca L. as well as Agave sisalan, whose root systems and/or fibers demonstrated high potential for increasing soil cohesion, reducing runoff and improving slope stability. The manuscript also discusses the influence of biodegradation processes, waterproof coatings and ecological interactions on the performance and durability of natural geotextiles. Studies conducted along the Lower São Francisco River and others demonstrated that nature-based stabilization systems combining biodegradable geotextiles, vegetation and ecological restoration significantly reduce sediment losses and enhance environmental resilience. The review reinforces the importance of integrating engineering, ecology and biodiversity-based technologies to develop sustainable solutions for erosion control and riverbank stabilization in tropical environments.

Introduction

Riverbank erosion and slope instability represent major environmental and socioeconomic challenges in tropical regions, particularly in areas under hydrosedimentological imbalance, vegetation removal and intense anthropogenic pressure [1].Along the Lower São Francisco River, northeastern Brazil, erosion processes have intensified due to river flow regulation by hydroelectric dams, wave action, groundwater fluctuations and the predominance of sandy, low-cohesion alluvial soils [2,3,4].These processes contribute to sediment losses, degradation of riparian ecosystems, reduction of agricultural areas and increasing instability of environmentally sensitive landscapes [5,6]. Conventional engineering techniques based predominantly on inert materials frequently present high implementation costs, low ecological compatibility and limited integration with restoration processes, reinforcing the need for more sustainable and multifunctional stabilization strategies [7,8,9].Within this context, Soil and Water Bioengineering has emerged as an important nature-based approach capable of integrating ecological restoration, vegetation establishment and geotechnical stabilization [10,11]. Studies developed by the Laboratory of Erosion and Sedimentation demonstrated that biodegradable geotextiles manufactured from natural fibers can significantly reduce runoff energy, sediment detachment and slope instability while simultaneously promoting vegetation establishment and ecological succession [12,13]. The biodiversity of tropical ecosystems also offers an important source of renewable fibers with favorable mechanical properties and environmental compatibility, including Typha domingensis Pers., Paspalum millegrana Schrad., Eleocharis sp. R.Br. and Syagrus coronata (Mart.) Becc.[14,15]. Recent technological advances involving waterproof coatings, digital image processing and scanning electron microscopy have further expanded the understanding of biodegradation dynamics, mechanical resistance and durability of natural geotextiles under tropical environmental conditions [16,24] .Furthermore, studies involving root biomechanics and vegetation-based stabilization systems demonstrated that native and tropical species play a remarkable role in increasing soil cohesion, improving shear resistance and reinforcing unstable slopes through root anchorage and soil aggregation processes [17,18]. The integration between deep-rooted vegetation and biodegradable geotextiles therefore represents an important transition from conventional inert engineering structures toward multifunctional nature-based stabilization systems capable of simultaneously promoting erosion control, ecological restoration and environmental resilience. In this context, the objective of this study was to provide an integrative overview of the scientific and technological advances developed by the Laboratory of Erosion and Sedimentation related to Soil and Water Bioengineering in tropical environments, emphasizing natural fiber geotextiles, riverbank stabilization, root reinforcement and ecological restoration strategies.

Material and Methods

This study was developed as an integrative scientific overview of the research conducted by the Laboratory of Erosion and Sedimentation (LABES/UFS) related to Soil and Water Bioengineering techniques in tropical environments of northeastern Brazil. The manuscript was structured through the compilation, critical integration and interpretative analysis of peer-reviewed scientific articles, technological reports and experimental studies produced by the research group over the last decades, emphasizing advances in biodegradable geotextiles, vegetation-based stabilization systems, riverbank erosion control, root biomechanics, ecological restoration and environmental monitoring. All literature cited throughout this study corresponds to scientific and technological production developed by LABES researchers and collaborators. The selected studies comprise experimental field trials, laboratory analyses, geotechnical evaluations, hydrosedimentological monitoring, scanning electron microscopy (SEM), digital image processing (DIP), tensile strength testing and ecological assessments conducted mainly along the Lower São Francisco River and associated riparian and other environments.The integrative approach adopted in this review was conducted in order to synthesize the technological, ecological and geotechnical contributions generated by the LABES/UFS research network, highlighting the evolution from empirical erosion control practices toward multifunctional nature-based engineering systems. The reviewed studies were grouped according to thematic axes involving root reinforcement potential, mechanical performance of natural fibers, biodegradation dynamics, biodiversity restoration, hydrodynamic processes and development of innovative geotextile manufacturing technologies. Particular emphasis was given to studies involving native and tropical species such as Paspalum millegrana Schrad., Typha domingensis Pers., Jatropha curcas L. and other biodiversity-derived fibers due to their relevance for ecological restoration and sustainable engineering applications. This methodological frameworkallowed the establishment of a comprehensive panorama of scientific and technological advances in Soil and Water Bioengineering developed by the Laboratory of Erosion and Sedimentation, emphasizing their applicability to erosion control, riverbank stabilization and ecological restoration in tropical environments.

Results and Discussion

Vegetation Root Reinforcement and Slope Stabilization

Developed Studies by this research group demonstrated the fundamental role of vegetation in soil and water bioengineering through root reinforcement, runoff reduction and slope stabilization in tropical environments. [19] showed that Paspalum millegrana presents high biotechnical potential due to its vigorous tillering, dense aerial biomass and extensive fasciculated root system, which increase soil cohesion, improve aggregation and reduce susceptibility to erosive and mass movement processes in unstable alluvial soils. Plant development was strongly influenced by phosphorus availability and soil moisture, with favorable conditions promoting greater root elongation and biomass production. The integration of Paspalum millegrana with biodegradable geotextiles strengthened nature-based stabilization systems by combining immediate surface protection with long-term ecological and geotechnical reinforcement.[20]expanded the understanding of vegetation biomechanics by demonstrating the importance of root architecture and spatial distribution for erosion control and slope stabilization. Using Digital Image Processing (DIP), SAFIRA software and geostatistical interpolation techniques, the study revealed that Paspalum millegrana develops a dense and deep root system exceeding 1.70 m in sandy soils, substantially increasing soil cohesion and resistance against mass movement processes. Complementarily, [21]demonstrated the allelopathic potential of Chrysopogon zizanioides (L.) Roberty and Paspalum millegrana, showing that aqueous extracts from roots and leaves may stimulate or inhibit seed germination depending on concentration and extraction method. These findings highlight that grasses used in erosion control systems interact not only through mechanical reinforcement, but also through biochemical and ecological mechanisms that influence vegetation establishment, ecological succession and biodiversity recovery in tropical restoration environments.

Contributions from Direct Shear Strength and Root Reinforcement Studies

[17] advanced the geotechnical understanding of vegetation-based stabilization systems by demonstrating the role of native shrub roots in increasing soil mechanical resistance in tropical riverbanks. Through direct shear tests on alluvial soils with and without roots of Solanum paniculatum L., Sesbania virgata (Cav.) Poir. and Mimosa pigra L., the study showed that root systems increase apparent cohesion, redistribute shear stresses and improve resistance against erosion and mass movement processes. Root-permeated soils, particularly those associated with Mimosa pigra, exhibited higher cohesion values, highlighting the importance of root morphology and spatial distribution for slope reinforcement. Complementarily,[18]demonstrated that Jatropha curcas presents high potential for Soil and Water Bioengineering due to its robust root architecture and high tensile resistance, combining deep pivoting and superficial roots capable of increasing soil cohesion, reducing runoff and minimizing sediment detachment in sandy tropical soils. Together, these findings reinforce the importance of integrating vegetation systems with biodegradable geotextiles for erosion control and ecological restoration in tropical riparian environments.

Natural Fiber Geotextiles and the Transition toward Sustainable Soil and Water Bioengineering

The biodiversity of tropical ecosystems represents an important source of renewable fibers with high potential for biodegradable geotextile production in Soil and Water Bioengineering. Studies involving Typha domingensis, Typha latifolia L., Eleocharis sp., Juncus sp. L. and Syagrus coronata demonstrated that these species combine ecological adaptability with favorable mechanical properties such as tensile resistance, flexibility and durability under environmental exposure[24].Characteristics including high cellulose and lignin contents, dense fiber bundles and silica-associated structures contribute to resistance against biodegradation while supporting ecological restoration in wetlands, riparian zones and semiarid landscapes. Natural fiber geotextiles have therefore emerged as sustainable alternatives to synthetic geosynthetics due to their biodegradability, renewability and compatibility with vegetation establishment and ecological succession[22,24].Their application is particularly relevant in tropical riverbanks affected by hydrosedimentological imbalance and erosion processes as well as on steep slopes along roadsides. Technological advances further expanded their applicability, with [23] developing geogrid-type geotextiles from Typha domingensis fibers using controlled drying, twisting, weaving and waterproof resin coatings, resulting in biodegradable meshes with high flexibility, tensile strength and durability for slope stabilization and riverbank protection.

Mechanical Resistance and Environmental Degradation

Mechanical performance is one of the main factors determining the applicability and durability of natural geotextiles under tropical field conditions subjected to rainfall, solar radiation, temperature variation and microbial activity[16,24].Studies demonstrated that Typha domingensis fibers exposed to environmental degradation exhibited progressive reductions in tensile strength over 180 days, whereas geotextiles treated with waterproof resin maintained higher mechanical resistance, stiffness and deformation stability[16]. Double-layer waterproof resin coatings reduced crack formation, minimized fiber deterioration and increased durability by more than 350%, reinforcing the importance of protective treatments for extending the useful life of biodegradable geotextiles. Additionally, scanning electron microscopy (SEM) and digital image processing have become important tools for evaluating biodegradation dynamics and fracture development. SEM analyses enabled detailed identification of microfractures and morphological alterations caused by environmental exposure, while resin-treated fibers exhibited smoother surfaces and lower fracture density compared to untreated materials. The integration of SEM with image-processing techniques represented an important technological advance for developing more resistant and environmentally compatible biodegradable geotextiles[24].

Environmental Functions and Ecosystem Services

[25]demonstrated that Soil and Water Bioengineering techniques enhance the ecological functionality of riverbank stabilization systems by simultaneously promoting erosion control and biodiversity recovery in tropical environments. Evaluating aquatic macrophyte communities along stabilized margins of the Lower São Francisco River, the authors identified 66 species distributed among 23 botanical families, highlighting the ecological potential of nature-based stabilization systems. Structures such as vegetated riprap, cribwalls and grass contour lines created favorable conditions for vegetation establishment, resulting in greater floristic richness and ecological resilience compared to eroded slopes. The study also showed that biodegradable geotextiles and vegetation systems contribute to nutrient cycling, sediment retention and habitat complexity, reinforcing their multifunctional role in river restoration strategies. In addition, field studies conducted in tropical environments demonstrated that natural geotextiles significantly reduce runoff and sediment losses while improving moisture conservation and vegetation establishment[13]. Experimental trials along the Lower São Francisco River showed that geotextiles manufactured from Syagrus coronata and Juncus sp. generated lower sediment losses than exposed soils and conventional treatments, while biodegradation progressively incorporated organic matter into the soil, contributing to ecological restoration processes.

Soil and Water Bioengineering, Riverbank Erosion and Geotechnical Processes

Riverbanks represents one of the most important natural laboratories for Soil and Water Bioengineering studies in tropical environments due to its intense erosion dynamics associated with hydrosedimentological imbalance and hydrological regulation. Studies demonstrated that riverbank instability in the region is controlled by the interaction between wave action, groundwater flow, slope geometry, soil texture, shear strength dynamics and hydrodynamic variables such as flow velocity, river discharge and quota oscillation [22,17]. Erosion processes are particularly severe in sandy and low-cohesion alluvial soils subjected to fluctuating water levels, with more than 83% of soil losses occurring outside the rainy season, highlighting the dominant role of fluvial hydrodynamics and dam-regulated flows over rainfall. The integration of erosion pins, bathymetric surveys and hydrodynamic monitoring provided an important methodological framework for understanding riverbank instability and optimizing stabilization strategies[3].Within this context, Soil and Water Bioengineering techniques integrating biodegradable geotextiles, vegetation, riprap and native species demonstrated strong potential for dissipating hydraulic energy, increasing soil cohesion, reducing sediment losses and enhancing ecological resilience in highly erodible riparian environments, while also improving ecological compatibility and reducing maintenance costs compared to conventional inert engineering approaches.

Circular Bioeconomy, Technological Innovation and Future Perspectives

Recent research developed by the Laboratory of Erosion and Sedimentation (LABES) reinforces the strategic role of circular bioeconomy principles in Soil and Water Bioengineering through the valorization of agroindustrial residues and sociobiodiversity-derived fibers for the production of multifunctional biocomposites and biodegradable geotextiles. New studies involving fibers from Cocos nucifera L., Ananas comosus (L.) Merr., Musa paradisiaca L. as well as Agave sisalana Perrine residues and Typha domingensis and Boehmeria nivea (L.) Gaudich., have expanded the development of innovative products such as geogrids, geocells, geocomposites, geodrains and geodiscs designed for erosion control, runoff dissipation, sediment retention, moisture conservation and ecological restoration in tropical environments. These biomaterials are also being applied in agricultural substrates and post-harvest solutions, contributing to degraded land recovery, improvement of soil quality and enhancement of climate-resilient production systems adapted to Brazilian edaphoclimatic conditions. This interdisciplinary approach strengthens the transition from conventional inert materials toward biodiversity-based technological solutions aligned with sustainability, low-carbon production systems and ecological resilience. Overall, the integrative framework presented in (Figure 1) reinforces that effective Soil and Water Bioengineering systems in tropical environments depend on the interaction among biodegradable natural fiber geotextiles, vegetation root reinforcement and ecological restoration processes. The developed studies showed that the combination of geotechnical stabilization, hydrosedimentological monitoring, biodiversity recovery and technological innovation contributes to sediment reduction, slope stability and enhancement of ecosystem services. These findings highlight the transition from conventional inert engineering approaches toward multifunctional nature-based solutions aligned with sustainability, ecological resilience and circular bioeconomy principles.

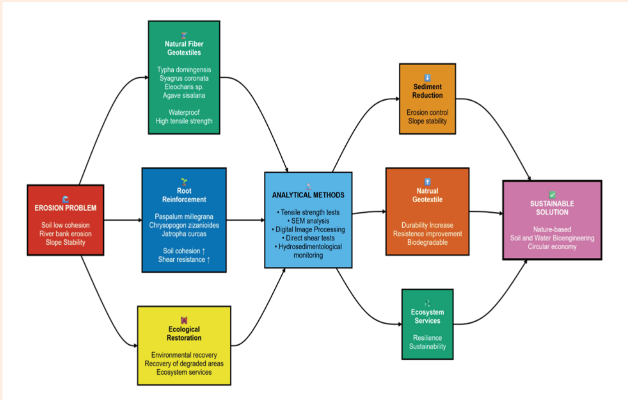

Figure 1. Nature-based Soil and Water Bioengineering framework highlighting natural fiber geotextiles, vegetation reinforcement and sustainable stabilization strategies.

Conclusions

Biodegradable geotextiles manufactured from natural fibers demonstrated high potential for reducing runoff, sediment losses and riverbank instability, representing sustainable alternatives to synthetic geosynthetics in tropical environments.Native and tropical species such as Paspalum millegrana, Jatropha curcas and Mimosa pigra significantly increased soil cohesion and shear resistance through root reinforcement, contributing to slope stabilization and ecological restoration processes.Technological advances involving waterproof resin coatings, scanning electron microscopy and digital image processing substantially improved the mechanical resistance, durability and biodegradation assessment of natural fiber geotextiles under tropical environmental conditions.Soil and Water Bioengineering techniques integrating vegetation, biodegradable geotextiles and ecological restoration promoted not only geotechnical stabilization but also biodiversity recovery, nutrient cycling and enhancement of ecosystem services in riparian environments.The studies developed by the Laboratory of Erosion and Sedimentation (LABES/UFS) demonstrated that nature-based engineering systems represent an effective and multifunctional strategy for erosion control, riverbank stabilization and environmental resilience in tropical regions subjected to hydrosedimentological imbalance and intense erosion dynamics.

Declaration of Competing Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Acknowledgements

The authors acknowledge the financial support provided by the National Council for Scientific and Technological Development (CNPq), the Coordination for the Improvement of Higher Education Personnel (CAPES), the Sergipe Foundation for Research and Technological Innovation Support (FAPITEC-SE), and the Federal University of Sergipe (UFS) over the years.

Generative Artificial Intelligence (AI)

We declare that Artificial Intelligence (AI), specifically ChatGPT, was used in the creation of (Figure 1).

References

1. Holanda FSR, Santos Lda,CG Araujo ,Filho RN, Pedrotti A, Gomes (2011) Conceição, FG. Perception of the riverine population on margin erosion and riparian vegetation deforestation in the lower São Francisco river. Ra'e Ga: O Espaço Geográfico Em Análise, 22, 219-237.
2. Holanda FSR, dos Santos, CM Casado, APB Bandeira, AA Oliveira (2007) Análise Multitemporal e Caracterização dos Processos Erosivos no Baixo São Francisco Sergipano. Revista Brasileira De Geomorfologia, 8:(2).
3. Rocha IP, Holanda FSR, Rolim MM, Lino JB, Araújo Filho RN (2018) Magnitude and spatiotemporal variation of the erosion on the slope of the Lower São Francisco River, Northeastern Brazil. Journal of Experimental Agriculture International, 24:(1), 1-11.
4. Holanda FSR, Santos MH, Jesus JB, Santos WM, Sena EOA (2021) Sediment input from the São Francisco River bank, Northeast Brazil, under low discharge period. Investigaciones Geográficas, 105, e60244.
5. Holanda FSR, Santos LGC, Santos CM, Casado APB,Pedrotti A (2005) Riparian vegetation affected by bank erosion in the Lower São Francisco River, northeastern Brazil. Revista Árvore, 29:(2), 327-336.
6. Moura MM, Fontes CS, Santos MH, Araujo Filho RN, Holanda FSR (2017) Estimativa de perda de solo no Baixo São Francisco Sergipano. Scientia Agraria,18:(2), 126-135.
7. Holanda FSR, Bandeira AA, Rocha IP, Araújo Filho, RN Ribeiro et al. (2009) Erosion controll on riverbanks: from empirical solutions to soil bioengineering techniques. RA'E GA - O Espaço Geográfico em Análise, 17, 93-101.
8. Santana IDM, Holanda FSR, Araújo Filho RN, Menezes AHB, Cruz JFV (2012) Potencial biotécnico das espécies Aroeira Schinus terebinthifolius Raddi e Sabiá Mimosa caesalpiniaefolia Benth para recuperação de taludes marginais no baixo São Francisco. Scientia Plena, 8:(4).
9. Araújo Filho, RN Holanda, FSR Pedrotti, A Santos, TO Lino, JB Rocha (2017) IP. Influence physicals-mechanicals properties in the stability of the slope in the lower São Francisco. Scientia Agraria,18:(4) 107-113.
10. Holanda FSR, Rocha IP, Oliveira VS (2008) Riverbank stabilization with soil bioengineering techniques at the Lower São Francisco River. Revista Brasileira de Engenharia Agrícola e Ambiental, 12: (6), 570-575.
11. Holanda FSR, Gomes LJ, Rocha IP, Santos TT, Araújo Filho (2010) Initial development of forest species on riparian vegetation recovery at riverbanks under soil bioengineering technique. Ciência Florestal, 20:(1), 157-166.
12. Holanda FSR, de Castro JDS, Santos LDV, de Andrade, CEC Griza (2020) Degradation of geotextiles of Typha latifolia Linn used in soil bioengineering techniques. Ciência Florestal, 30:(4), 1147-1160.
13. Fontes CS, Holanda FSR, Araújo Filho RN, Santos LDV, Lino JB, Moura MM (2021) Erosion control with geotextiles manufactured from natural fibers in the margin of São Francisco River. Caminhos de Geografia, 22:(84) 25-35.
14. Araújo Filho, RN, Holanda, FSR, Santana, IDM, Santos, TO, Primo, DC (2015) Efficiency of simple super phosphate in the vetiver grass development subjected to soil bioengineering. Revista Caatinga, 28:(2) 1-9.
15. Holanda FSR, Santos LDV, Melo JCR, Pedrotti A, Sussuchi EM et al. (2025) Influence of Sodium Hydroxide Treatment on Typha domingensis Fibers for Geotextile Manufacturing. ACS Omega ,10:(2) pp 450602.
16. Holanda FSR, Santos LDV,Melo JCRD, Boge GM, Sussuchi EM (2024) Resistance of the fiber-derived geotextile from Typha domingensis submitted to field degradation. Sci. Rep. (14) pp 8648.
17. Rocha, IP, Holanda, FSR, Rolim, MM, Pedrotti, A, Moura, MM, Santos, LDV (2021) Direct shear strength on the São Francisco River Bank, Northeastern Brazil, with or without roots of different native species. Journal of Agricultural Studies, 9:(1),146-170.
18. Ferreira, OJM, Holanda FSR, Pedrotti A, Santos LDV, Silva-Mann R(2022) Root system of Jatropha curcas provides resistance and strengthens to the soil. Communications in Soil Science and Plant Analysis, 53:(22) 2955-2967.
19. Holanda FSR, Lino JB, Santos MH, Garcez TB, Araújo Filho (2017) RN. Biotechnical potential of Paspalum submitted to simple superphosphate doses and moisture content. Scientia Agraria, 18:(4), 43-49.
20. Carvalho AM, Santos LDV, Holanda FSR, Pedrotti A, Antonio GM (2020) Digital image processing for evaluation of Paspalum millegrana Schrad root system. Revista Caatinga, 33:(1) 100-107.
21. Costa E C, Holanda FSR, Sussuchi,EM, Bomfim LS, Araújo Filho RN (2020) Allelopathic potential of Chrysopogon zizanioides (L.) and Paspalum millegrana (Schrad) on the germination of lettuce. Iheringia, Série Botânica, 75, e2020002.
22. Holanda FSR, Araújo Filho RN, Pedrotti A, Wilcox BP, Marino RH, (2021) Soil Bioengineeringin northeastern Brazil: An overview. Ambiente Água - An Interdisciplinary Journal of Applied Science, 16:(4) e2650.
23. Santos LDV, Holanda FSR, Pedrotti A, Lino JB, Fontes CS, (2024) Geogrid-type geotextile made from Typha domingensis fibers with high tensile strength for erosion control. Invention Disclosure, 4, 100025.
24. Santos LDV, Holanda FSR, Barbosa Filho JJM, Oliveira WF, da Silva EG (2025) Analysis of fracture characteristics and biodegradation resistance of natural fibers geotextiles from Typha domingensis, Eleocharis sp., and Syagrus coronata under waterproofing resin. Discover Applied Sciences, 7: (7), 751.
25. Santos MH, Holanda FSR, LinoJB, Santos TLS, Fontes CS (2020) Macrophytes communities associated to Soil Bioengineering techniques for erosion control in riverbanks. Iheringia, Série Botânica, 75, e2020011.