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EXPLORING THE INFLUENCE OF ARTIFICIAL ROOT SYSTEMS MODELED AFTER MARRAM GRASS (AMMOPHILA ARENARIA) ON DUNE EROSION

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1 INTRODUCTION

Vegetated dune systems represent a remarkable landform along numerous coastal areas worldwide. They provide a valuable contribution to local ecosystems and coastal protection. The influence of vegetation on the stability of soils potentially counteracts erosion and, on sandy coasts under suitable conditions, leads to the accumulation of sediments driven by aeolian transport, resulting in dune formation (Feagin et al. 2015). The assessment of the coastal protection potential of dunes is far from being a streamlined, mature procedure, and it will demand more parameters than merely the dunes' height, dimensions or volume, but tentatively also their vegetation coverage. Artificial dunes or dunes regenerated through sand nourishment often lack additional substrate stabilization since no vegetation bound root systems are present (Nordstrom and Jackson 2022). The role of stabilizing root components in the overall dune body matrix is currently not well understood, in particular, when highly dynamic processes such as wave attack is involved. The hypothesis of this novel work hence is that root systems of dune grass (i.e., *A. arenaria)* can be quantified for the modelling in experimental campaigns and for more reliable erosion results. To investigate this hypothesis novel physical experiments are currently conducted in the wave flume at the Leichtweiß-Institute for Hydraulic Engineering and Water Resources in Braunschweig (Germany), testing different root surrogate materials and quantities for the first time.

2 METHODS

For the physical model tests, a 1:7 Froude scaled dune with a volume of 3.89 m³ is built in the wave flume (90 m length, 1 m width, 1.5 m height, see Figure 1c)). It is subjected to various hydraulic boundary conditions in a 2D fashion.

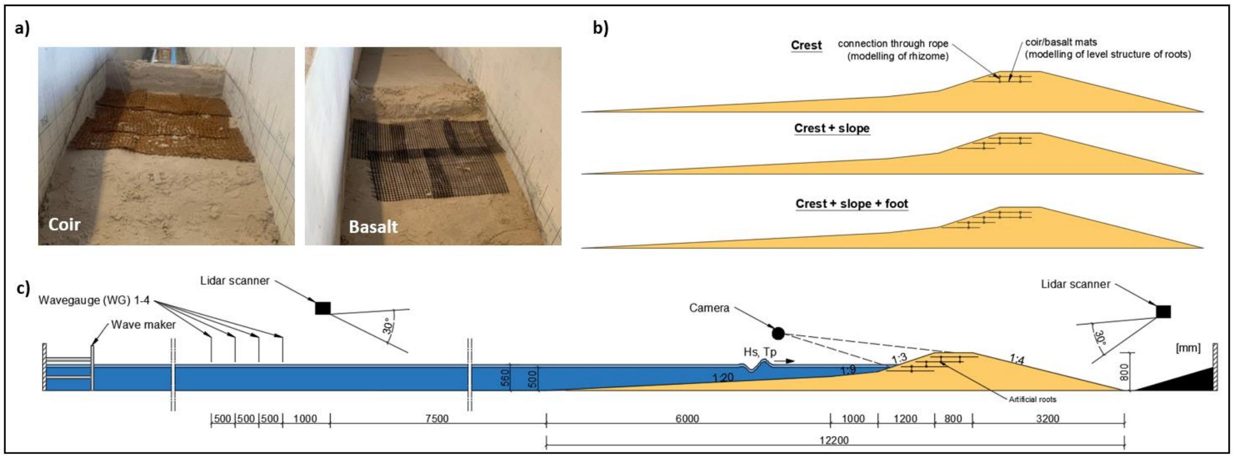

Figure 1. Experimental setup including: a) photographs from the dune model installation with different mats, sketches of b) investigated root model implementations and c) experimental setup overview.

This work models the natural root system by a surrogate, artificial root system which is based on *A. arenaria*, a common marram grass at the European coastline. Because roots of *Ammophila arenaria* are growing horizontally at intermittent stages forming terrace- or rope ladder-like structure, the artificial root surrogates were installed in horizontally-oriented layers, with a vertical distance of 10 cm each other and with a maximum burying depth of 20 cm from the surface (see Table 1).

Table 1. Natural and scaled root properties (Kutschera et al. 1982)

	Vertical root level distance [cm]	Max. root depth [cm]	Horizontal root spreading [cm]
Prototype	70	162	310
Laboratory (length scale 1:7)	10	23	44
Used in experiment	10	20	44

Experiments are conducted permuting the following conditions: (i) three different materials as artificial roots (coir mats in a form of a grid, basalt mats and coir mats with loose fibers); (ii) the artificial roots are installed in three different ways to investigate the position of roots influencing the erosion, only at the dunes crest, at the dunes crest and slope and at the dunes crest, slope and foot (see Figure 1b); (iii) three different storm surge scenarios are tested in the experimental program (Scenario A: d=50cm, H_s=18cm, T_p=2.8s, collision regime; Scenario B: d=56cm, H_s=14cm, T_p=2.3s, collision and overwash regime; Scenario C: d=56cm, H_s=18cm, T_p=2.8s, overwash regime), each lasting 113 min while using a JONSWAP spectrum. To measure the profile changes, two LIDAR scanner are installed, one in front of the dune and one behind it. The scanners are measuring the profile before, after and during the tests with a sampling rate of 0.7 Hz. Furthermore, a wave gauge array with 5 resistive wave gauges (RWGs) is installed in the wave flume to record the incident wave conditions (see Figure 1c).

3 PRELIMINARY RESULTS

Preliminary results indicate a positive correlation between artificial root systems being installed and recorded erosion reduction. The work we present will elucidate quantitative results, with the ambition to correlate our laboratory findings with in-situ observations, however we note, that large-scale verifications are at the forefront of current research ambitions. Figure 2 exemplary displays the final profile of two tests with and without artificial roots resulting from scenario B. Herein an erosion reduction due to the installation of the artificial roots system can be seen. This work will be the first coordinated effort to represent the role and effects of below-ground biomass on the erosive behavior of dunes, with an emphasis on reproducible results, by using surrogate material.

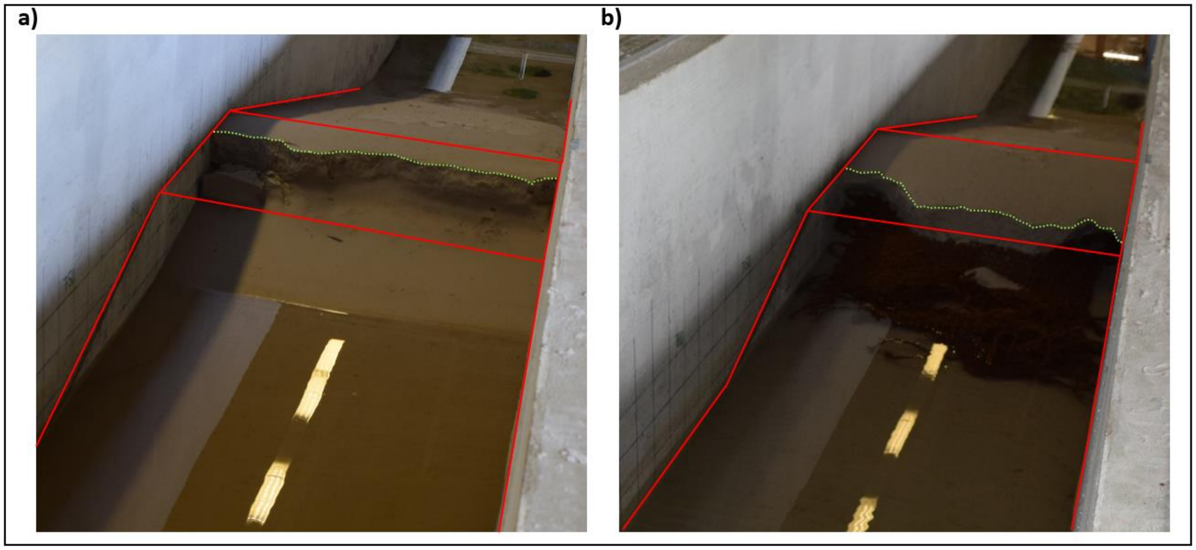

Figure 2. Experimental results from: a) after the test scenario B with no artificial roots; b) after the test scenario B with coir mats as grid built in the crest. The red lines show the initial dune profile geometries and the green dotted lines the final crest erosion.

REFERENCES

Feagin, R. A., Figlus, J., Zinnert, J. C., Sigren, J., Martínez, M. L., Silva, R., Smith, W. K., Cox, D., Young, D. R., & Carter, G., 2015, Going with the flow or against the grain? The promise of vegetation for protecting beaches, dunes, and barrier islands from erosion. Frontiers in Ecology and the Environment, 13(4):203-210. https://doi.org/10.1890/140218

Kutschera-(Mitter) L. and Lichtenegger E., 1982, Wurzelatlas mitteleuropäischer Grünlandpfl anzen. Bd. 1: Monocotyledoneae. – Stuttgart, New York: Gustav Fischer. [Bd. 2 der Wurzelatlasreihe]

Nordstrom, K. F., & Jackson, N. L., 2022, Beach and dune restoration, Cambridge University Press, Online ISBN: 9781108866453, https://doi.org/10.1017/9781108866453