Relating grass cover strength to vegetation and soil parameters using a grass pullout test

Rens van der Meijden, University of Twente, r.vandermeijden@utwente.nl
Gosse Jan Steendam, Infram Hydren, gosse.jan.steendam@infram-hydren.nl
Jord Warmink, University of Twente, j.j.warmink@utwente.nl
Denie Augustijn, University of Twente, d.m.augustijn@utwente.nl

INTRODUCTION

Earthen dikes in the Netherlands often comprise an erosion-resistant, but species-poor grass cover. Alternatively, species-rich (i.e. containing a large number of grass and herb species) grass covers, due to their deeper and more diverse root networks, are hypothesized to be stronger than conventional covers. To pave the way for the nation-wide application of species-rich covers, the Future Dikes project investigates whether existing species-rich dikes are sufficiently erosion resistant. Strength assessments are done using the wave overtopping simulator (WOS) (Van der Meer et al., 2007) at 3 locations and a grass sod pulling method (SPM) at 20 locations (Bijlard et al., 2017). Both tests derive a critical velocity (U_c) to characterize the strength of species-rich covers in the design and assessment protocols. However, in the past, relating the results of the SPM to the WOS and environmental (root, soil) parameters was sometimes difficult, hence questioning the consistency of the device. To assess the consistency of the SPM, this study will unravel the relations between measured grass cover strength and various vegetation and soil characteristics. In doing so, insight may be obtained into the contribution of species-richness to grass cover strength as well.

DATA AND METHODS

The SPM consists of a tripod and a pull frame, which is mounted to a grass sod. Driven by an electric motor, the sod is pulled from the cover vertically, whilst recording the applied force and displacement. The peak force (i.e. at the moment when the sod fails) is translated to a critical normal stress (N/cm^2) by division over the surface area of the sod. Per dike section, 30 pullout tests are performed within an area of 8 m x 5 m. The data used in this study were acquired during two projects: Gras op Zand (GOZ, conventional grass on sand) and Future Dikes (FD, species-rich grass on silt). Both data sets include, besides sod pulling tests, extensive field research into above-ground vegetation coverage, root weight, soil granular and fertility characteristics. The mean and coefficient of variation (CV) of the 30 critical normal stresses per dike section are related to the recorded vegetation and soil characteristics. First, an exploratory Principal Component Analysis (PCA) reveals the large-scale variability and strongest relations in the datasets, after which a Redundancy Analysis (RDA) assesses whether the strength data can be explained by the environmental data in a statistically significant manner.

PRELIMINARY RESULTS

Figure 1 shows a biplot of the PCA scores and loadings based on the combined data of FD and GOZ. Besides species-richness ($N_{species}$) and coverage of herbs (%), the sites in FD and GOZ are distinctly different in terms of above-ground vegetation coverage (%), lutum and sand fractions (%), microbial activity (MicrAct) and pH. Results have shown that the critical normal stresses of FD are highest. Detailed analysis should reveal the contribution of species-richness.

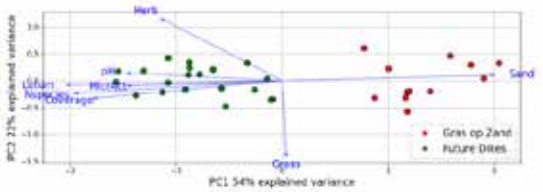

Figure 1 PCA biplot of the combined FD and GOZ data.

Figure 2 shows an RDA biplot of the GOZ data, wherein the variance of the mean and CV of the critical normal stress (CNS) is for 85% explained using 8 vegetation and soil parameters. This indicates that the magnitude and variability of the measured strength using the SPM are largely in line with what would be expected from the present vegetation and soil characteristics. In Figure 2, species-richness and increased herb coverage seem not to contribute significantly to the cover strength. However, they may affect the dry weight of (fine) roots, which will be further analyzed in the paper.

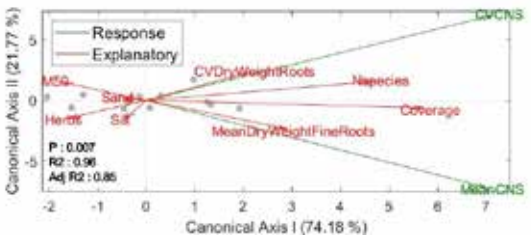

Figure 2 RDA biplot of the GOZ data.

ACKNOWLEDGEMENTS

Future Dikes is funded by the Dutch Flood Protection Program, on whose behalf Waterboard Rivierenland fulfils the role of client. The project is carried out by a consortium consisting of Radboud University Nijmegen, Wageningen Environmental Research, University of Twente, Infram Hydren, Eureco Advies, Deltares and Lumbricus Environmental Research and Consultancy.

REFERENCES

Bijlard, R., Steendam, G. Verhagen, H., & Van der Meer, J. (2017). Determining the critical velocity of grass sods for wave overtopping by a grass pulling device. *Coastal Engineering Proceedings*, *1*(35). https://doi.org/10.9753/icce.v35.structures.20

Van der Meer, J. W., Bernardini, P., Snijders, W., & Regeling, E. (2007). The wave overtopping simulator. *Coastal Engineering 2006*, 4654-4666. https://doi.org/10.1142/9789812709554_0390