Linking plants, fungi and soil mechanics

Anil Yildiz [1,2,3] & Frank Graf [1]

(1) WSL Institute for Snow and Avalanche Research SLF, Davos Dorf, Switzerland
(2) Swiss Federal Institute for Forest, Snow and Landscape Reserch WSL, Birmensdorf, Switzerland,
(3) ETH Zurich, Zurich, Switzerland.

anil.yildiz@wsl.ch graf@slf.ch

plant-specific functions related to slope stability

- hydrological
  - interception
  - evapo-transpiration
- mechanical
  - root reinforcement
  - structural changes

requires growth and development on superficial soil layer

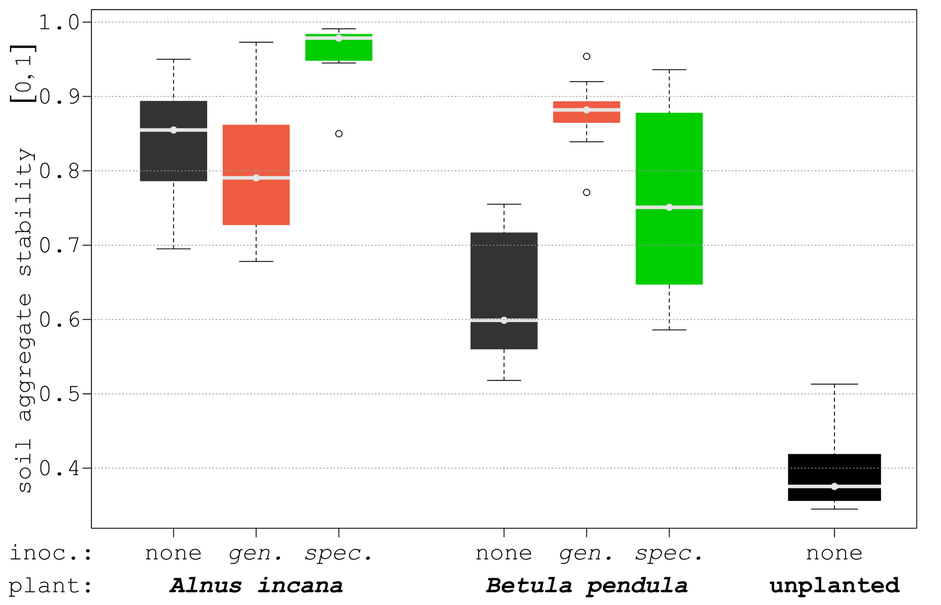
characterised by

- lack of fines
- predominantly formed by coarse grains
- low water retention capacity
- substantial leaching of nutrients
- missing stable soil matrix and pore structure

plants

aggregates > 2 mm

- soil aggregates as «bricks» for a stable soil matrix and pore structure
- enhanced and accelerated development of root systems due to symbiotic fungi
- fine roots vs. coarse roots
- «root reinforcement»
  - a combination of fungal mycelia and root networks
  - growth and development of the protective vegetation
    - → aggregate strength controlling potential
    - → efficiency
    - → sustainability



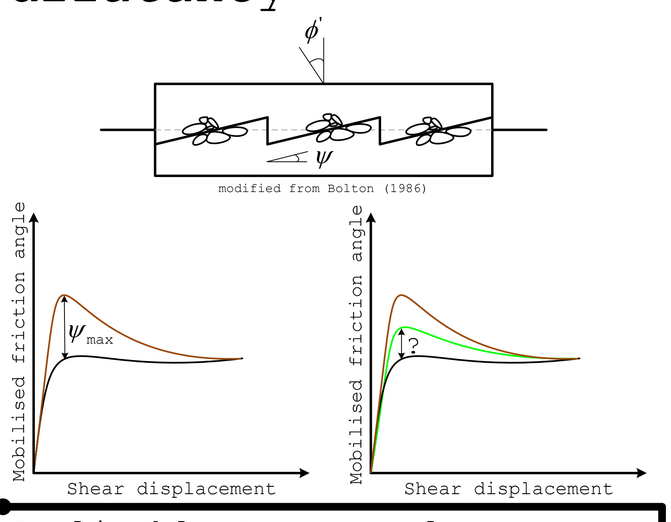
fungi

aggregates < 2 mm

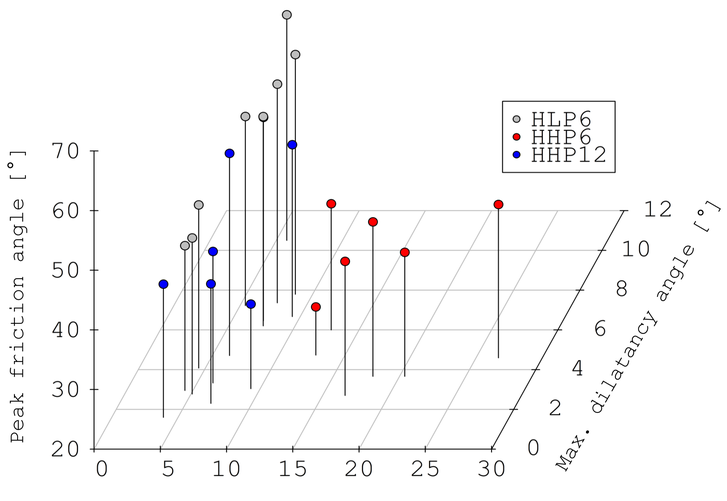
- supply the hosts with water and nutrients
- a resilient soil matrix with micro- and macro-aggregates
- enmesh small organic and inorganic soil particles
- form and cement the particles to micro- and macro-aggregates
- able to align primary particles
- exert pressure on surrounding particles
- net negative charge under neutral pH values
- clay minerals are bound to negatively charged surface of fungal hyphae

soil mechanics

dilatancy

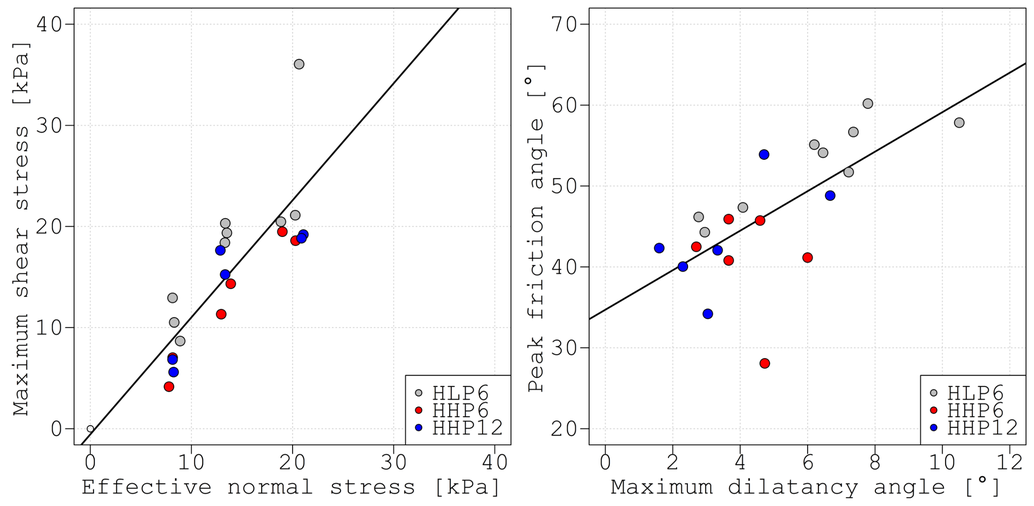


- exclusively frictional failure envelope
- unplanted: 40.4° DS tests (Yildiz et al. 2015)
  34.3° triaxial tests (Graf et al. 2009)
- «root cohesion» : stress independent
  anchoring
- «change in friction angle» : stress dependent
  change in soil structure



Inclinable Large-scale Direct Shear Apparatus

ildsa



$\tau_{max} = -0.56 + \sigma' \tan 49.2^{\circ}$ $\phi'_{max} = 37.7^{\circ} + 2.44\psi_{max}$

aggregation of fines
~
characteristics of coarse-grained soils
~
higher values of shear strength
~
angle of internal friction, ϕ'

This study is funded by Swiss National Science Foundation within the framework of the National Research Programme "Sustainable Use of Soil as a Resource" (NRP 68, Project no. 143122).

IGT Institute for Geotechnical Engineering ETH Zürich

WSL Institute for Snow and Avalanche Research SLF

Swiss Federal Institute for Forest, Snow and Landscape Research WSL

FNSNF

Bolton, M.D., 1986. The strength and dilatancy of sands. Géotechnique 36, 65-78. doi:10.1680/geot.1986.36.1.65

Graf, F., Frei, M., Boll, A., 2009. Effects of vegetation on the angle of internal friction of a moraine. For. Snow Landsc. Res. 82, 61-77.

Yildiz, A., Askarinejad, A., Graf, F., Rickli, C., Springman, S.M., 2015. Effects of roots and mycorrhizal fungi on the stability of slopes, XVI ECSMGE Geotechnical Engineering for Infrastructure and Development, pp. 1693-1698.