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Shear Strength

To determine the shear strength of our soil samples we used the shear strength apparatus applying a vertical force of 300 kPa. The apparatus shears the upper layer and the lower layer 1.5 cm against each other and measures the force needed (Figure 1). The further the layers are sheared against each other the higher force needed. Different soil textures have different shear strengths. At one point sand reaches maximum shear strength and remains on this plateau whereas the shear strength of humus declines after the maximum is reached. Moreover the apparatus measures the soil water content and the settlement of the particles in the sample.

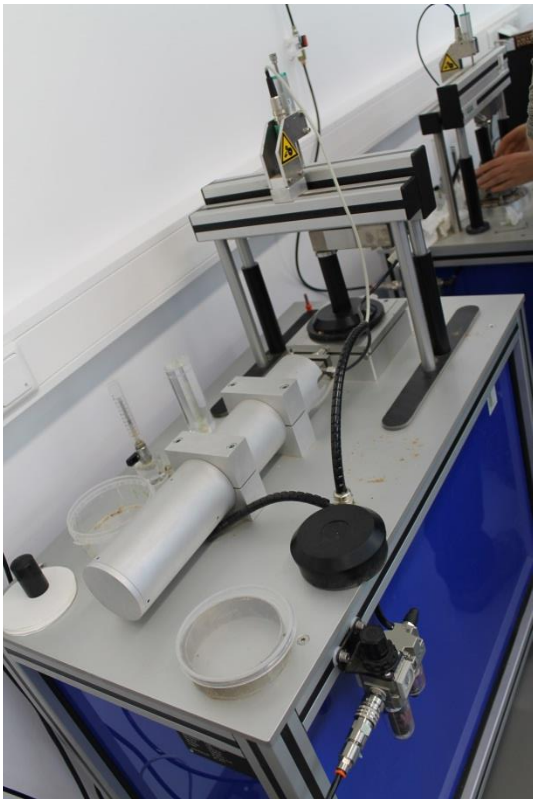


Figure 1: Device to measure the shear strength.

Compaction Ability

The compaction ability is measured with the compression apparatus (Figure 2). A vertical force is gradually applied on the soil sample and the compression depth noted. Humus can be compacted almost ten times as much as sand and has a higher precompression rate. For the precompression rate depends on both the soil water content and structure, more water aspirers from the humus sample.

Both methods above are used in agricultural contexts to determine the soil resistance against mechanical forces such as heavy machines.

Figure 2: Device to measure the soil compaction.

Soil Water Capacity

Soil samples of different textures have different soil water capacities and therefore contain different amounts of water. These can be measured by weighing the fresh sample and subtracting the dry weight (Figure 3). Analogously the total soil water capacity can be measured after previous saturation of the sample.

Figure 3: Scale used to weigh the soil samples.

Field Capacity

The field capacity is the soil water content of a sample after drainage of full saturated sample by gravity only. The samples are put on top of a sand body for two days preventing evapotration and due to capillarity and gravity most of the water is sucked out. The remaining water, held back by the soil with adhesion and cohesion, is called field capacity. Therefore sand has for example a lower field capacity than humus.

Plant available Water

Gravimetric soil water content does not tell much about water availability. Therefore, a pressure box is used to measure how much plant non-available water remains in a certain type of soil under given pressure. From this data, pF curves are constructed elucidating the relationship between soil water and soil water potential, the later a measure of plant water availability.

At highly negative water potentials, plants will die even though there is technically sill water remaining in the soil. This water is called the plant non-available water and is strongly bound to the soil particles by physical forces, for example adhesion.

Soil Permeability

Soil permeability is the ability of a porous material to allow fluids to pass through it. To measure the permeability of the soil the sample is saturated overnight first. After that it is put into a fixation device and a water flux through the sample is generated (Figure 4). Measuring the volume of water passing through the soil over a certain time, the speed of the water flux can be determined. This leads to a value which allows a comparison of different soil types.

Figure 4: Device to measure the soil permeability.

Soil Profile

<u>Location:</u> Estonian University of Life Sciences, Kreuzwaldi 64, close to Laboratory Building (The red lightning in Figure 5 indicates the sampling location)

<u>Site:</u> meadow, Devonian sediments, high vegetation cover (100%), old field succession, nitrogen rich (Indicator: *Urtica dioica*) (Figure 6)

Plant species: *Urtica dioica, Artemisia vulgaris,_Cirsium arvense, Tanacetum vulgare, Trifolium pratense, Agropyron cristatum, Anthriscus sylvestris, Vicia cracca, Lamium album, Sonchus sp., Achillea millefolium*

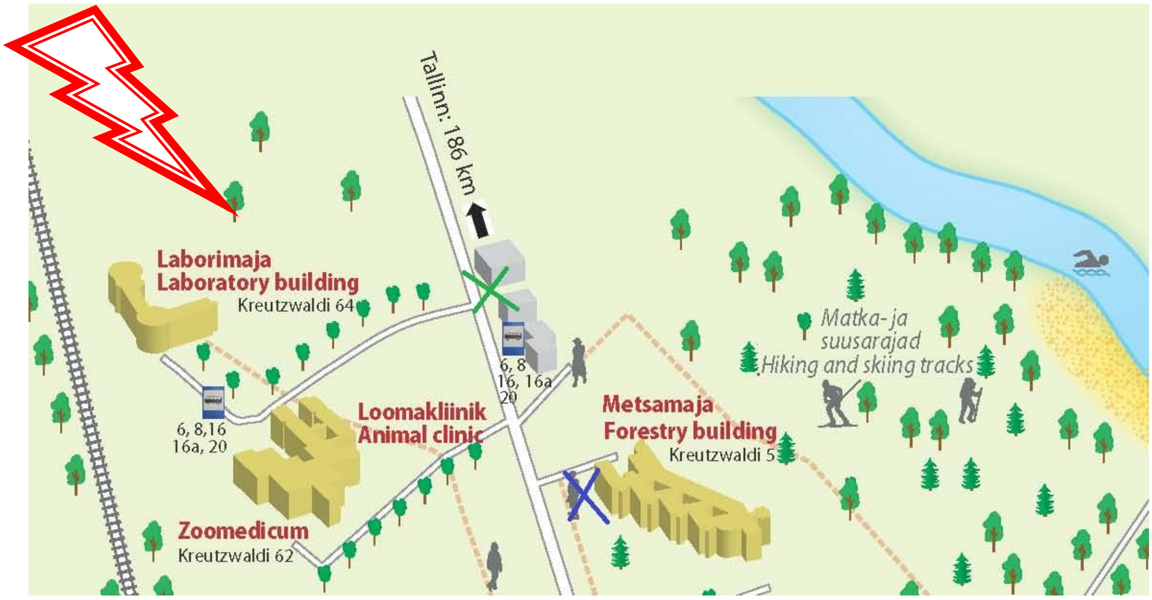


Figure 5: Map of Estonian University of Life Sciences. The red lightning indicates the sampling location.

Figure 6: Sampling site with vegetation cover including two international students digging a hole.

To show the profile of a certain soil we dug a hole measuring 0.5 x 0.5 x 1 m. Using a key we distinguished the texture of the different soil layers. The color was matched with the Munsell color chart for each soil layer (Figure 8). We also determined the pH using universal indicator (Figure 9). The lime content can be shown by spilling HCl on the soil. If lime is contained it leads to bubbles. Our soil profile did not show a reaction (Figure 10). This led to the following soil profile which is classified as Luvisol (Table 1, Figure 7).

Table 1: Soil profile including the depth, texture, pH, and color of the different soil horizons.

depth [cm]		texture	pH	color
0 - 43	A-horizon	L_S	5.6	7 5YR 3/2
43 - 56	E-horizon	S_L	6.8	7 5YR 5/4
56 - 83	B-horizon	L_S	6.8	2 5YR 4/8
83 - 100	C-horizon	L	7.0	5YR 4/6

Figure 7: Soil profile.

Figure 8: Munsell color chart.

Figure 9: pH measurement with universal indicator. **Figure 10: HCl test for lime content.**

Soil Compaction

To detect the degree of soil compaction in the different layers we used the Eijkelkamp Penetrologger seen in Figure 11. It is inserted in the ground using virility. The strength needed is displayed and a compaction profile is evaluated.

Figure 11: Device to measure the soil compaction.

Soil Water Content – Percometer

The percometer is used for measuring the water content and salt content of a soil. It detects the electric conductivity by sending electrical signals in the ground (Figure 12).

Figure 12: Percometer used to measure the soil water content and salt content.

Lectures

<u>Soil compaction (Reintam)</u>

Definition: Compaction of the mineral and organic matter in soil reducing pore sizes, particles pressed together

Causes:

- natural: raindrops impact
- anthropogenic: tillage compaction in agriculture => heavy soil compaction
  Wheel traffic => major cause of soil compaction

Consequences:

- It reduces the capacity to save water
- Effect on soil bulk density
- On compacted soils, there is no effect of using fertilizer
- Difficulties for plants to take root and spread its root system in the soil
- Affect soil organisms, e.g. decline of the amount of earthworms

⇨ The best protection of the soil are the plants

Plant stress biology (Kazda)

Def: Stress

- **In human biology**: reaction to a change that requires a physical, mental or emotional adjustment
- **Plant stress**: State in which increasing demands made upon a plant lead to an initial destabilisation of functions.

Plant and their environment:

Abiotic factors	**Biotic factors**
Temperature	Competition
Water	Herbivory
CO_2, O_2	Pollination & dispersal
Nutrients	Parasitism
Soil properties	Symbiosis
Chemicals	Allelopathy
Human-induced	Microbial interactions

Most common plant stress factors

- Drought
- Temperature
- Flooding
- Excess of salts or heavy metals
- Deficiency or excess in nutrients
- Mechanical stress: wind, snow
- Soil compaction
- Herbivory

Adaptations

- Hardening

Focus on drought stress:

Reasons for insufficient water supply:

- Climatic: ratio precipitation/evaporation, predictability of precipitation
- Site specific: aspect, water storage capacity in soil

Conditions:

- water shortage: low water potential often accompanied by increasing osmolarity of the soil solution
- Slow water transports to the roots
- Higher soil temperature

- Impaired mineralisation of soil nutrients
- Changes in cost/benefit ratio of the fine roots

Growth conditions under drought

- Dry air (high water vapour pressure deficit)
- High radiation
- High air temperatures
- High leaf temperatures
- Low soil availability
- Ionic imbalances
- Often low oxygen supply to the roots

Salt stress:

- Dehydration
- Ionic stress
- Alkalisation

<u>Interactions between soil and plants (Astover)</u>

Plant growth is precondition for soil formation

Soil forming factors are: - Time
- Climate
- Organisms
- Plants!

Plants are:

- Initial source of organic matter (CNPS cycling, “feed” for soil biomass, raw material for humification)
- Soil miners

What plants need from soil

- water
- mineral nutrients
- suitable conditions for root development

The main interaction zone is the rhizosphere
Root architecture – nutrient/water location, but also physical constraints

Mechanisms of nutrient uptake

- Diffusion (high concentrations => low concentrations)
- Mass flow (with water, longer distances) (Root interception)
- Foliar uptake: plants can take water and minerals from the air through le leaves
- Mycorrhiza (up to 80% of higher plants species, up to 90% of P…)

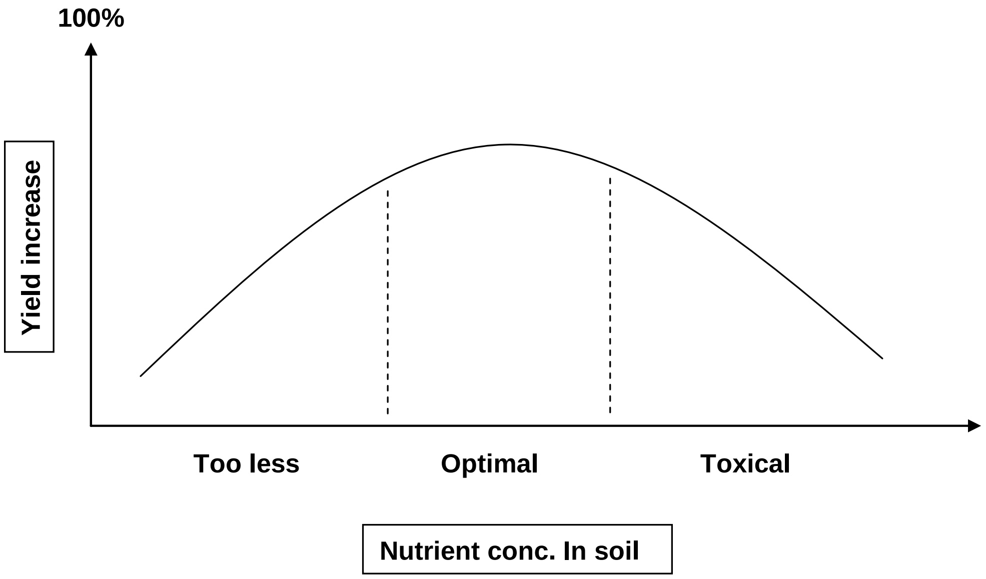
Nutrient mobility in soil:

- very mobile: NO_3^-, sulphate, S, B
- Moderately mobile: NH_4^+, K^+, Ca_2^+, Mg_2^+…
- Immobile: P, Cu, Fe, Mn, Zn

Nutrient availability depends on pH!

Example: Hydrangea (Hortensia)
Some species of this genera change their colours depending on soil pH
=> acidic = blue, neutral = pink

Optimal nutrient concentration:



Soil is quite resistant:

- soil is like a bank

⇨ "you get money very easy but when you don't pay it back, you'll probably get into trouble."

Final comment: Plants are good indicators of soil quality!