MSc thesis project (April-Sept. 2017):

Interaction of plant nutrition and drought stress in *Aspalathus linearis*, the South African leguminous shrub used to produce Rooibos Tea

Aspalathus linearis (Burm. F) Dahlg. (Crotolarieae, Fabaceae)

Brief description:

The semi-arid areas of South Africa where rooibos (*Aspalathus linearis,* Crotalarieae, Fabaceae) is cultivated are threatened by desertification due to intensive agricultural production on extremely nutrient and organic matter poor sandy soils[1]. Both low nutrient availability and drought severely limit rooibos growth, which is what an on-going PhD project on possible beneficial microbe-supported ecological intensification measures is currently addressing in the Group of Plant Nutrition at ETH (https://www.ethz.ch/content/specialinterest/dual/world-food-system-center/en/research/MRP/ecoint.html). Soil management may target plant supply with nitrogen (N) and phosphorus (P) and drought tolerance, all of which are strongly influenced by microbial root symbioses[2]. The South African rooibos farming suffers from severe nutrient and water availability constraints, which in part may be overcome by plant-beneficial microbes[3]. The project explores whether mineral nutrients collected by sheep from the surrounding natural vegetation and beneficial microbes striving in soil from nearby wild populations of rooibos could make rooibos grow better in nurseries and plantations.

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Project:

This MSc thesis project will test whether mixing together soil from wild populations and plantations, along with addition of sheep dung for seedling production (= nursery stage), can enhance rooibos' N, P, and micronutrient acquisition and drought tolerance. Incorporating soil from the wild into soil from plantations is likely to increase the presence of root symbionts and to dilute and competitively combat plant microbial antagonists. This is expected to make mineral nutrients plant-available through the symbiotic interactions with rhizobia, which fix atmospheric N_2, and arbuscular mycorhizal fungi (AMF), which store and enhance plant P uptake. Because of mineralisation over several months, sheep dung added to soil will release sufficiently little P at a time to avoid P toxicity, but make rooibos grow bigger[4]. Any small increase in soil organic matter, either from soil of wild populations, or from the sheep manure, will improve the nutrient and moisture conditions in the sandy soil. The combination of microbiologically and nutritionally improved soil is expected to boost rooibos growth.

Data acquisition and analysis will involve counting of root nodules and cluster roots, determination of shoot and root dry weights, as well as of N and P concentrations in the

shoots. Nitrogen measurement by isotopic ratio mass-spectrometry (IR-MS) will simultaneously yield the $\delta^{13}C$ and $\delta^{15}N$ signatures, and P measurement by inductively coupled plasma mass spectrometry (ICP-MS) the concentrations of several micronutrients important for legume functioning. The $\delta^{13}C$ and $\delta^{15}N$ signatures are indicative of relative drought stress exposure and relative microbe- versus plant- mediated N acquisition. Overall, the study will also record an exceptional plasticity of rooibos in expressing different specialised nutrient acquisition strategies, depending on relative N and P availability[5].

The MSc student is expected to work closely together with the PhD student of the project and to join him for the harvest of a 600 pot-experiment currently running in Stellenbosch, South Africa, as well as sharing the collected data with him. Analyses in the laboratory will take place at the Research station Lindau-Eschikon (https://www.ethz.ch/en/campus/locations/zurich-region/lindau-eschikon.html). The starting date must agree with the harvesting of the pot experiment planned in April 2017. Students of the Agricultural Sciences can apply for reimbursement of the travel expenses by the Walter Hochstrasser Stiftung (https://www.fundraiso.ch/sponsor/walter-hochstrasser-stiftung/). Other students may want to try to get reimbursement by *Funds Welternährung* of the World Food Systems Center of ETH, or any other student support fund.

For further information on the formal MSc project requirements see:
https://www.usys.ethz.ch/en/studies/agricultural-sciences/master/thesis.html
https://www.usys.ethz.ch/en/studies/environmental-sciences/master/thesis.html

Major: Ecology and Evolution, Crop Science

Group work: Not possible

Season: April-September 2017

References:

[1]Lötter D, le Maitre D. 2014. Modelling the distribution of *Aspalathus linearis* (Rooibos tea): Implications of climate change for livelihoods dependent on both cultivation and harvesting from the wild. *Ecology and Evolution* 4(8): 1209-1221.

[2]Hassen A, Bopape F, Habig J, Lamprecht S. 2012. Nodulation of rooibos (*Aspalathus linearis* Burm. f.), an indigenous South African legume, by members of both the α-Proteobacteria and β-Proteobacteria. *Biology and Fertility of Soils* 48(3): 295-303.

[3]Bender SF, Wagg C & Van der Heijden M. 2016. An underground revolution: Biodiversity and soil engineering for agricultural sustainability. *Trends in Ecology and Evolution* 31(6): 440-452.

[4]Power SC, Cramer MD, Verboom GA & Chimphango SBM. 2010. Does phosphate acquisition constrain legume persistence in the fynbos of the Cape Floristic Region? *Plant and Soil* 334(1): 33-46

[5]Maistry PM, Muasya AM, Valentine AJ, Chimphango SBM. 2015. Increasing nitrogen supply stimulates phosphorus acquisition mechanisms in the fynbos species *Aspalathus linearis*. *Functional Plant Biology* 42(1): 52-62.