Using microfluidics for improving agriculture in rural Kenya

Agriculture is the very foundation of our modern society; without reliable access to food, our world stops. But even though our agriculture is more productive than ever, it is still facing huge challenges. Today, there are over 800 million people living in hunger, and our unsustainable use of fertilizers and pesticides puts immense pressure on both ecosystems and soil health. It is clear that we need to find new ways to create an effective and sustainable food system to sustain our global population. In this thesis, we have taken microfluidic chips from the Nanolab in Lund out to the fields in rural Kenya to investigate one possible solution to this.

East Africa is currently facing many challenges in food supply with recent draughts and shortages in global grain supply. This has led to a serious situation with many alarming reports of food crisis, but also initiatives for finding new and effective solutions. One attempt for increasing agricultural food production in the region, in a sustainable and self-reliant way, is by enriching the soil with biochar.

Biochar is a locally produced compound that is very similar to regular charcoal. It has been shown that when enriching soil with biochar, it improves many aspects of the soil that helps it produce more food. An ongoing study in Kenya has shown that a single biochar addition increased yields over several seasons and years. If this could be applied in a systematical manner, it could play an important part in overcoming the challenges of hunger and sustainable food production. But before doing so, we need to know more about how biochar affects the soil and soil microbes.

Soil is full of microscopic life, such as bacteria, fungi, and single-cell organisms, that is essential for any well-functioning agriculture. In a single spoon of soil there are billions of microbes, and these microbes break down nutrients which then become available for plants. In this thesis, we have studied how biochar-enrichment of soil affects the microbial life in the soil. We looked into if biochar-enriched soils had more or less of these microbes, and if the microbes were better or worse at finding food. We did this by using a newly developed analysis tool using microfluidic chips. With the chips, we can imitate how soil operates at the microscopic level, and when a chip is dug down in the soil, microbes will populate the chip as if it was real soil. We can then analyze the chip and see how many microbes entered the chip, and how far they have grown into the chip.

We found that microbes in biochar-enriched soils had fewer fungi when compared to regular soil without biochar. But these fungi were better at growing deep into the chip, indicating that they are better at searching for food in the soil. We also saw that biochar-enriched soil had more single-celled organisms, *protists*, than soil without biochar. Additionally, we show that we can successfully employ this technology, across continents, in low-resource areas to study the microscopic life in soil. This gives rise to the possibility for similar future studies, which can help us understand how to reach a more effective and sustainable agriculture, worldwide.

Popular science summary of Master's Thesis: *Microbial ecosystem analysis of biochar-enriched soil in Kenya using microfluidic soil models*. Erik Karlsson. Faculty of Engineering LTH, Lund University, Sweden.