LegumeSELECT: Science-driven Evaluation of Legume Choice for Transformed livelihoods

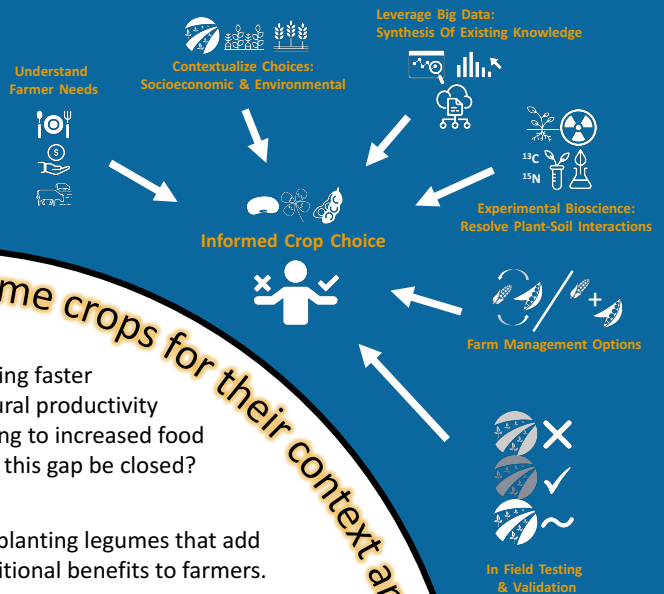## LegumeCHOICE- a decision support framework

The LegumeSELECT project lead by the University of Edinburgh is addressing a major question that underpins the adoption of multi-purpose legumes in Sub-Saharan Africa: which legumes perform best and deliver the benefits farmers demand, under which conditions and management practices, for enhanced smallholder farm productivity?

Our goal: is to increase the contribution of legumes to the livelihoods of farmers by further developing LegumeCHOICE, a decision support framework, by combining existing data with new data from experimentation. We are going to resolve the interactions between the characteristics of different legumes with soils, and match these to individual farm biophysical and socioeconomic contexts. This will provide knowledge and tools to help smallholder farmers in making decisions for smart integration and use of multi-purpose legumes for an enhanced production environment.

Where are we working?
Our research is focused on the smallholder farming systems of Western Kenya, Ethiopia, and Eastern DR Congo. These systems vary in how they are managed and grow staples such as maize, barley, millet, banana, cassava, tef and potato.

A multi-scale, multi-disciplinary research approach

Understand Farmer Needs

Contextualize Choices: Socioeconomic & Environmental

Leverage Big Data: Synthesis Of Existing Knowledge

Experimental Bioscience: Resolve Plant-Soil Interactions
^{13}C ^{15}N

Informed Crop Choice

Farm Management Options

In Field Testing & Validation

Helping African famers choose the best legume crops for their context and needs.

PROBLEM:
The population is growing faster than current gains in agricultural productivity in Sub Saharan Africa. This is leading to increased food and nutrition insecurity. How can this gap be closed?

Solution:
Improve crop yields and soil fertility by planting legumes that add nitrogen to the soil but also provide additional benefits to farmers.

But how do farmers choose the best legume for their specific context that meets their multiple, immediate needs?
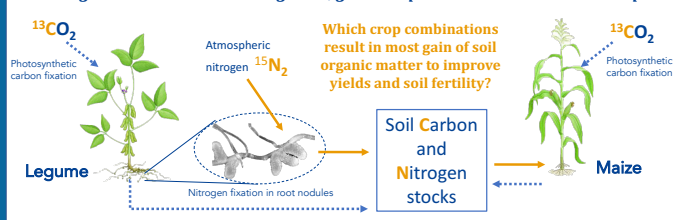
Legume Species
Cowpea = beans
Clover = manure
Soya = multipurpose

Management Scenarios
Intercropping
Rotation
Green manure addition

Environmental Context
Soil fertility
Rainfall patterns
Temperature

Stable Isotopes

^{13}Carbon

^{15}Nitrogen

We are using the naturally occurring heavy isotopes of carbon and nitrogen atoms, ^{13}C and ^{15}N, as markers in our experiments. They allow us to trace and quantify how much Nitrogen different legumes contribute to improving soil fertility and the yields of other crops such as maize. They also allow us to understand how different legumes interact with organic matter in soils so we can tell which management practices lead to net gains or losses of Carbon from soils. Increasing soil organic matter also improves fertility especially in poorer soils.

Resolving interactions between legumes, grain crops and soils with stable isotopes:

$^{13}CO_2$
Photosynthetic carbon fixation

Atmospheric nitrogen $^{15}N_2$

Which crop combinations result in most gain of soil organic matter to improve yields and soil fertility?

$^{13}CO_2$
Photosynthetic carbon fixation

Legume

Nitrogen fixation in root nodules

Soil Carbon and Nitrogen stocks

Maize

X-Rays of roots

"Seeing in the dark"

We are employing state of the art **micro-CT X-Ray** technology to allow us to visualize the root systems of live plants without having to dig them up. This is effectively like seeing in the dark where it is otherwise very difficult to measure anything about roots without removing them from soil first.

micro-CT X-Ray 3D reconstruction of an intact undisturbed root system:
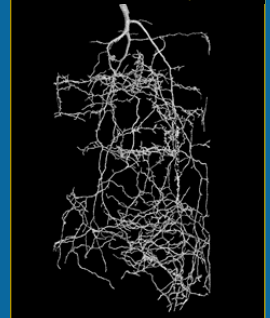
By using **X-Ray tomography techniques** we are elucidating how the three dimensional structure of root systems relate to the contributions legumes make to the availability of nitrogen in soils under different management practices. Roots can be scanned repeatedly to track how a plant explores and exploits soil resources over time. The impact of root systems on the physical properties of soils can also be quantified such as changes to soil porosity and the capacity of soils to retain water.