Beyond biological nitrogen fixation: Legumes and the Sustainable Intensification of smallholder farming systems

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[with many colleagues and partners]
The astonishing flexibility of legumes
A legume for all cropping systems...

Banana – bush bean intercropping

Banana – climbing bean intercropping

Innovative maize-soybean intercropping

Calliandra hedgerows for fodder and erosion control

Innovative cassava-bean intercropping

Putting nitrogen fixation to work for smallholder farmers in Africa
…that also benefits the associated crop!

maize following maize

maize following climbing beans

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The legume paradox

Annual grain legumes

- Grain
- Fuel
- Protein
- Mulch
- Fodder
- Fixed nitrogen

Perennial grain legumes

- Grain
- Fuel
- Protein
- Mulch
- Fodder
- Fixed nitrogen

Proportion of agricultural land under legumes (%)


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Intensification is a must!
Intensification for forest conservation

DR Congo

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Slash-and-burn systems

Productivity vs. Soil fertility / natural resource status over time.
No realistic alternatives in densely populated areas

Kenya

Intensification of agriculture
Shortened/absent fallows

Productivity

Soil fertility / natural resource status

Time
Soil degradation: increasingly complex

Crop yield vs. Time (or degradation status)

- Nutrient imbalances
- Other degradation

Soil fertility status
Soil degradation: increasingly complex

Crop yield vs. Soil fertility status over time (or degradation status)

- Nutrient imbalances
- Other degradation
Sustainable Intensification
Agronomy/productivity principles

(i) **Production** of more food, feed, fuel and/or fiber per unit of land, labor, and/or capital used

(ii) Conservation and harnessing of **ecosystem services**, including those delivered by healthy soils and biodiversity

(iii) **Resilience** to shocks and stresses, including climate change

**Enabling conditions**

→ **Economic** (profitability and equity)

→ **Social** (culture, gender, participation)

→ **Human** (food security and nutrition)
Pathways towards SI

Soil fertility / natural resource status

Payment Envir. Serv.; other incentives

Market incentives; agro-input systems; etc

Upward arrow: Productivity

Soil fertility / natural resource status
Kofi Anan: “a uniquely African Green Revolution” recognising the diversity of peoples, soils and farming practices
Smallholder farming systems and legumes: household diversity
Value of production (VOP): calculated by taking total harvests and multiplying it by the price, then divided by the size of the household.
Uganda smallholder farmers (IITA datasets)

Legend

GPS datasets
- IFAD
- LSMS
- PASIC - potato
- PASIC - rice
- USAID

Other datasets
- Impact Lite - Hoima
- Impact Lite - Rakai
- ZOA

Scale: 0 50 100 150 200 km
Household diversity

District Moyo

UGX / year / capita

Farmer

Crops
- cassava
- pigeonpea
- sweetpotato
- sorghum
- groundnut
- other

Van Asten, Mandy, et al

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0 50 100 150 200 km
Household diversity

District Koboko

UGX / year / capita

Farmer

Crops
- cassava
- beans
- maize
- groundnut
- simsim
- other

Van Asten, Mandy, et al

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Household diversity

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0 50 100 150 200 km

S-Sudan
DR Congo
Household diversity

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Climbing bean yields in NW Rwanda

Franke et al, 2016
Climbing bean yields in NW Rwanda

Franke et al, 2016
Smallholder farming systems and legumes: within-farm variability
Small farms with heterogeneous fields

0.5 – 1 ha

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Small farms with heterogeneous fields

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Soil heterogeneity affects response

Fertilizer application to beans in Rwanda

(c) Beans in Rwanda

(b) Beans in Rwanda

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Soil heterogeneity affects responses.

Fertilizer application to beans in Rwanda.

(c) Beans in Rwanda

Cumulative frequency

Bean yield (kg ha$^{-1}$)

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Soil heterogeneity affects responses

Inoculant and P fertilizer application to soybean in Nigeria

Ronner et al, 2016

Soybean grain yield control (kg ha⁻¹) vs. Soybean grain yield with P and/or I (kg ha⁻¹)

- P
- I
- P+I

Ronner et al, 2016

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Soil heterogeneity affects responses

Inoculant and P fertilizer application to soybean in Nigeria

Ronner et al, 2016
Residual effects reflect heterogeneity

→ 120 legume-cereal fields
→ 24 from East, 20 from southern, and 76 from West Africa
→ 38 unique publications

Franke et al, 2016
Some final thoughts
Grain legumes commonly have multiple benefits and acreages under these crops have increased but remain low in most part of SSA.

Different pathways exist towards Sustainable Intensification of smallholder agriculture; intensifying legume production follows the productivity logic and requires enabling conditions.

A ‘typical’ household and a ‘typical’ legume plot do not exist; lack of resources led to diversity in farms and fields in densely populated areas.

Households are diverse as is their interest/investment in legume production; in specific case studies, poorer and female farmers demonstrated less climbing bean productivity.

Soil fertility gradients affect yields, responses, rotational benefits; diversity of options to boost productivity; targeting interventions is key!

Although legumes have multiple benefits, what appears to matter most is market access!
Thanks for listening!

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