Biofortification and Improvement of the Iron-to-Phytate Molar Ratio in two Yellow Common Bean (Phaseolus vulgaris L.) Varieties in Tanzania

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Monday, 27th August, 2023

Outlines

- Introduction
- Problem statement and Justification
- Objectives
- Materials and Methods

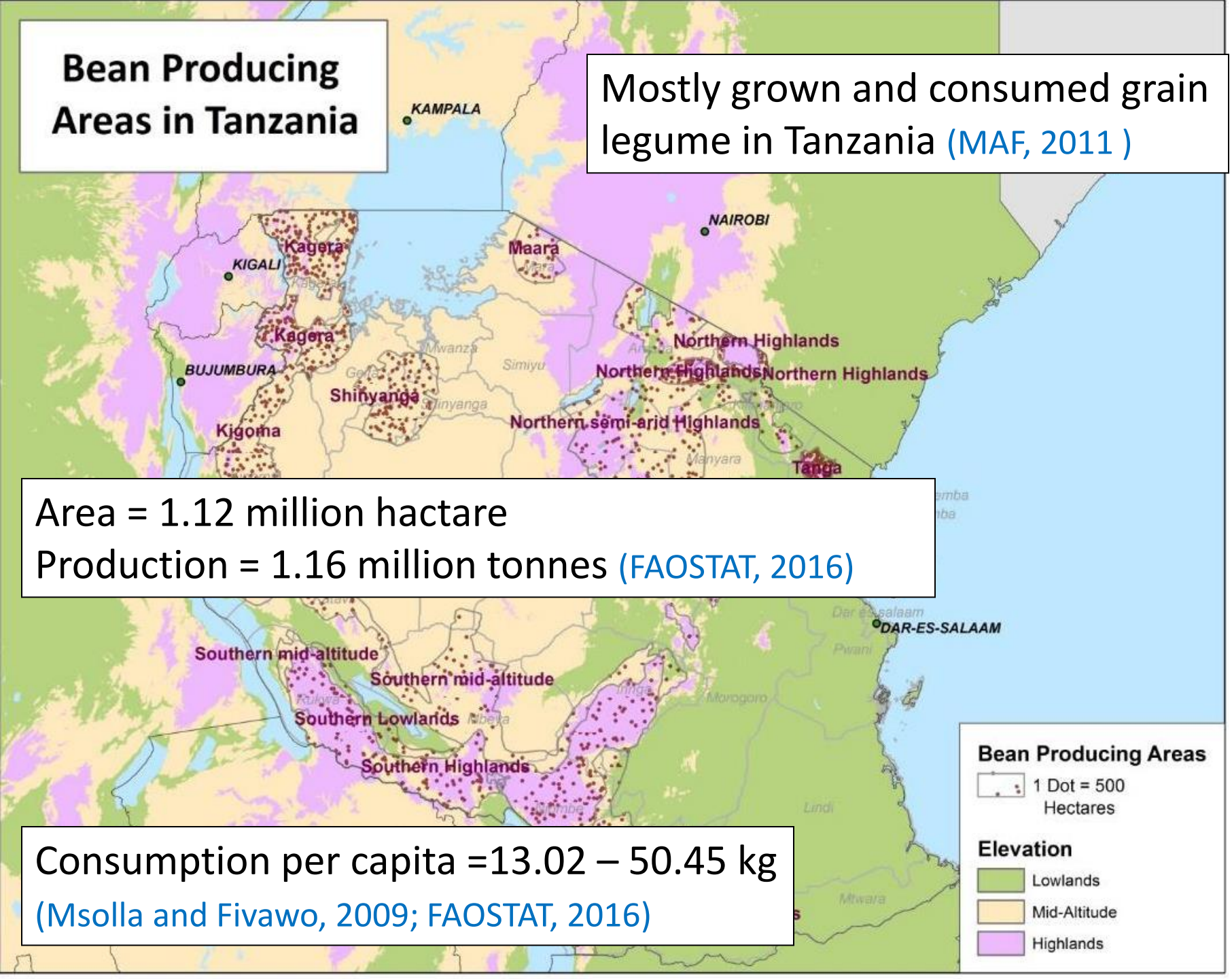
Introduction

Bean belongs to Fabaceae family and mainly self pollinating (75 – 100%)

Originated from South and Central America (Mexico and Guatemala)

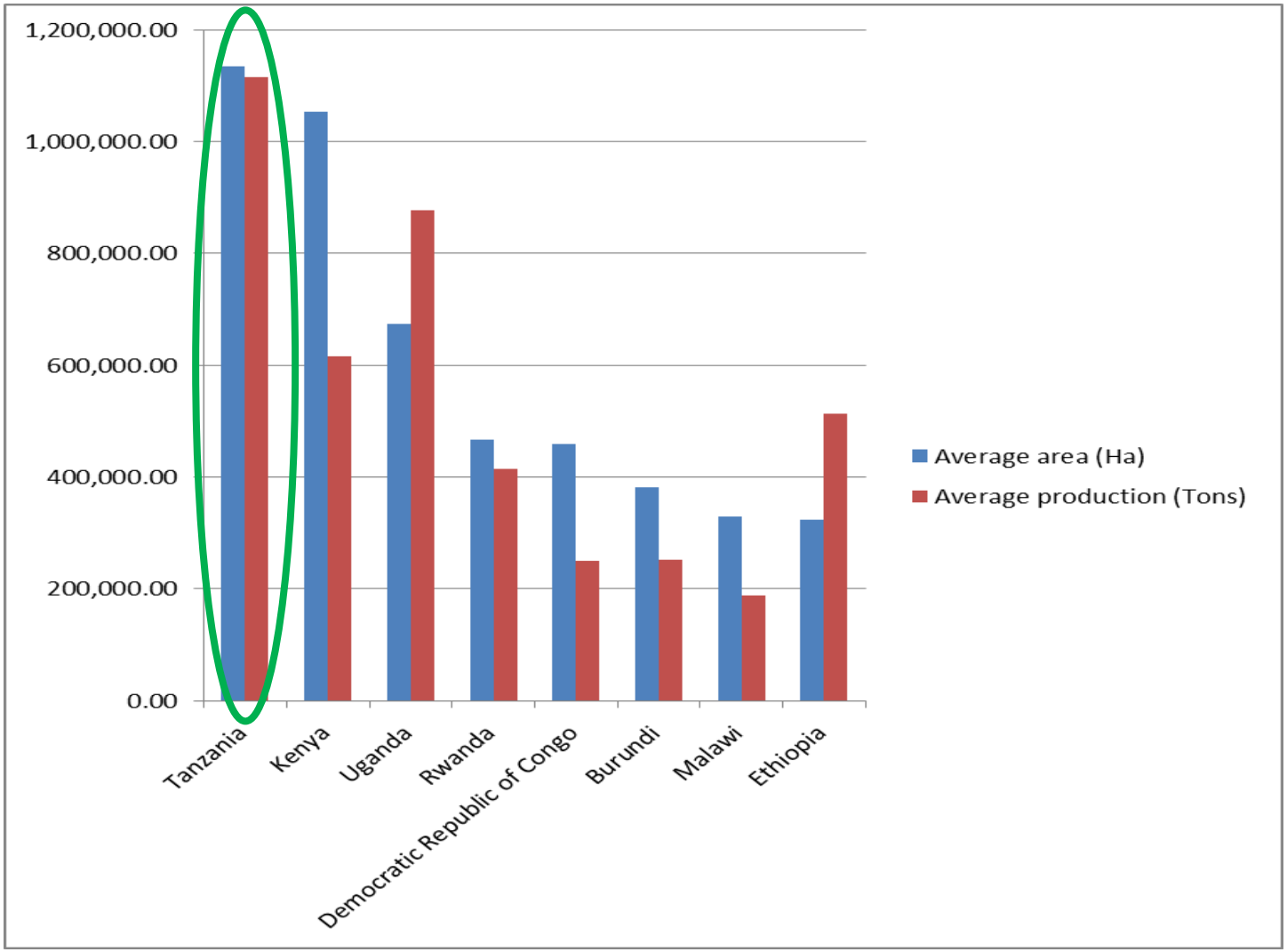
Protein= 15 -30%
Iron= 30 -110 ppm
Zinc= 25 – 60 ppm
Fiber=16.81 to 40.63%
Folate= 1.5 – 6.8 ppm
(Blair,2003)

Income
Local and external market (Export to more than 10 countries) (Binagwa et al., 2016)


Bean Producing Areas in Tanzania
Mostly grown and consumed grain legume in Tanzania (MAF, 2011)
KAMPALA
NAIROBI
KIGALI
Kagera
Maara
Kagera
BUJUMBURA
Shinyanga
Kigoma
Northern Highlands
Northern Highlands
Northern Highlands
Northern semi-arid Highlands
Tanga
Area = 1.12 million hactare
Production = 1.16 million tonnes (FAOSTAT, 2016)
DAR-ES-SALAAM
Southern mid-altitude
Southern mid-altitude
Southern Lowlands
Southern Highlands
Consumption per capita =13.02 – 50.45 kg
(Msolla and Fivawo, 2009; FAOSTAT, 2016)
Bean Producing Areas
1 Dot = 500 Hectares
Elevation
Lowlands
Mid-Altitude
Highlands

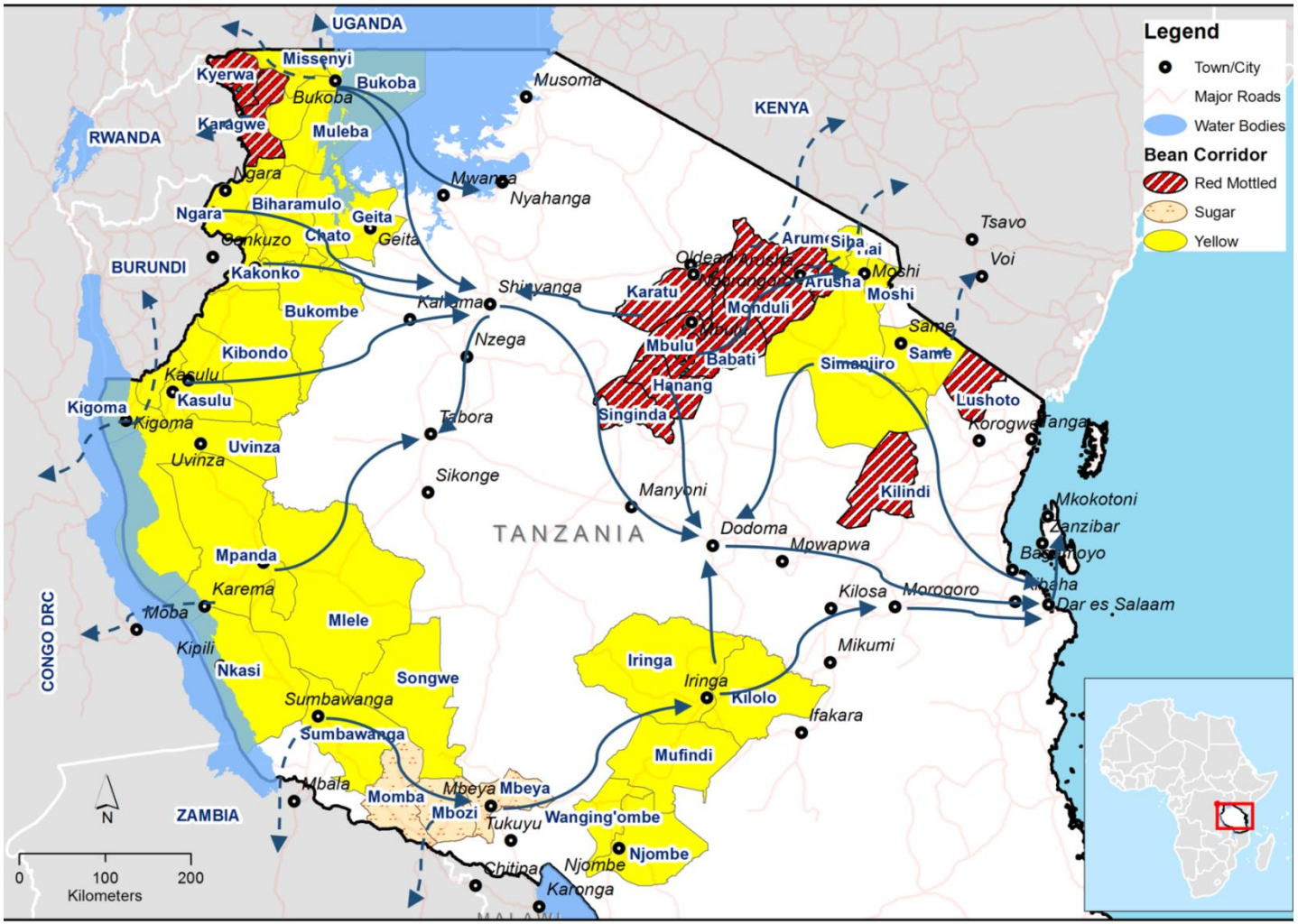
Introduction Cont....

- Tanzania is the largest producer of common bean in Africa



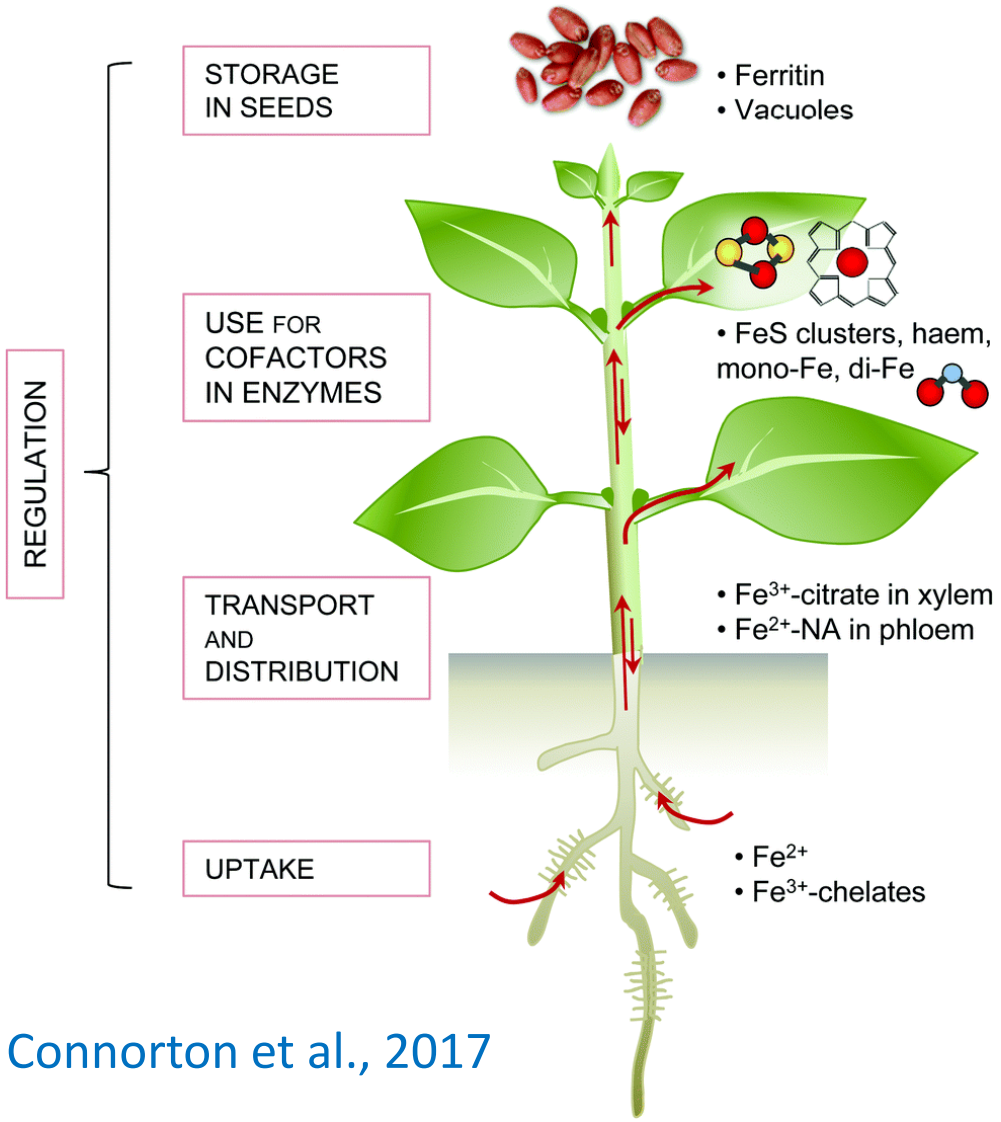
Source: FAO, 2014

Map of Tanzania showing Main bean type grown in Bean growing areas



- **Yellow bean preferred due to;**
  - Seed color
  - Early maturing
  - Short cooking time
  - Good taste
  - Low gas (flatulence) production

Introduction Cont….



Connorton et al., 2017

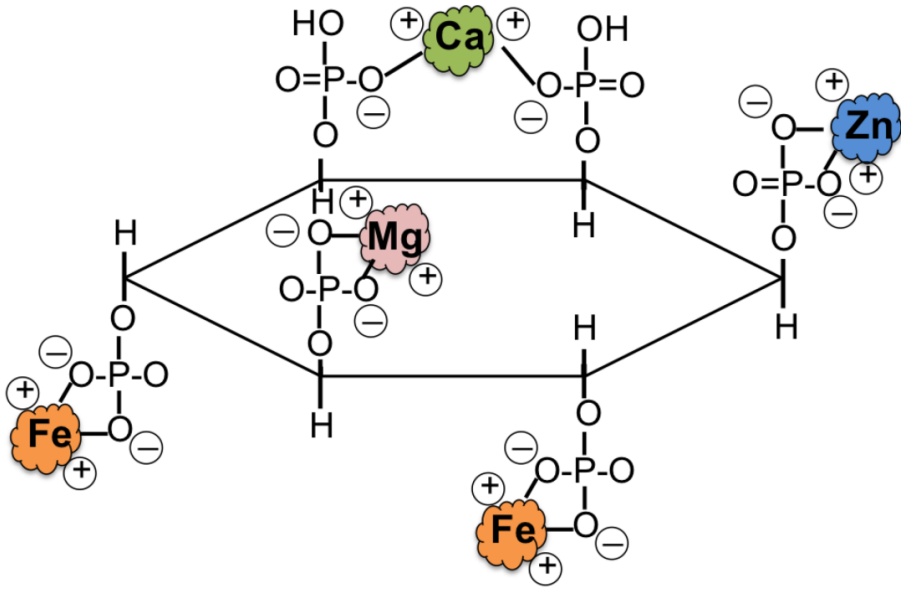
- Plants, are the gateway for Fe and other essential minerals to enter the food chain
- The main source of minerals (Fe) in humans is through dietary intake of food rich in Fe such as beans
- Improving the contents of Fe in beans would improve their consumption by humans

Problem statement and justification

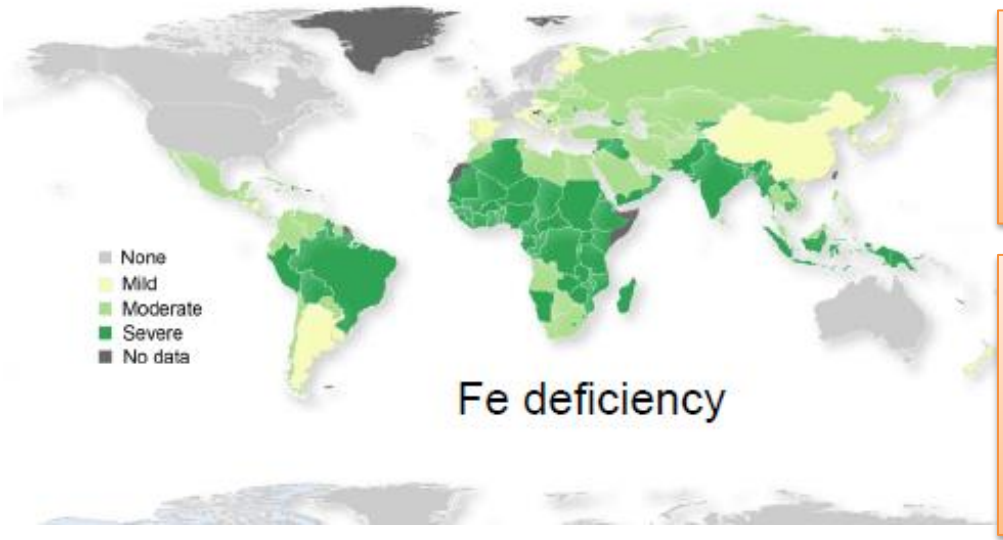
- The widely grown and consumed yellow common bean varieties in Tanzania have a relatively;
  - ✓ low seed Fe content ≤ 45.0 mg/kg, and
  - ✓ high seed PA content ≥ 1203 mg/100 g (Tryphone & Nchimbi-Msolla, 2010; Bucheyeki & Mmbaga, 2013; Philipo et al., 2020),
- Compared to the recommended value of ≥ 70.0 mg Fe/kg for common beans (Kimani & Warsame, 2019).
- The PA-to-Fe molar ratio of Tanzanian yellow beans is ≥ 27.6 and thus very high.

Problem statement and justification cont…

- PA Inhibits absorption of nutritional Fe, Zn, Mg and Mn in human gut, due to lack of Phytase enzymes (Petry et al., 2013; Sparvoli and Cominelli, 2015)



Micronutrient deficiencies are a global human health concern



- 2 billion people suffer micronutrient deficiencies globally (WHO, 2016)
- 41% of children under 5 years and 35% women have Fe deficiency anemia in Tanzania (NBS and ICF Macro, 2011)

Problem statement and justification cont.…

- To address the Fe deficiency and high PA:Fe challenges in the Tanzania's widely consumed yellow common bean varieties, this study will focus on:
  - Screening selected bean genotypes for Fe, and PA, across diverse sites
  - Crossing the high seed Fe and low PA-containing bean genotypes with the widely consumed yellow common bean varieties
    - To increase seed Fe, and
    - Reduce the PA: Fe molar ratio for high bioavailability of Fe in human gut

Objectives

Overall Objective

To evaluate seed Fe and PA concentration of the common bean genotypes and increase Fe contents while lowering PA:Fe molar ratio into seeds of the widely consumed yellow common bean varieties for improved Fe intake in Tanzania

Specific Objectives

i. To determine levels of Fe, PA and yield of common bean genotypes in five bean growing areas of Tanzania

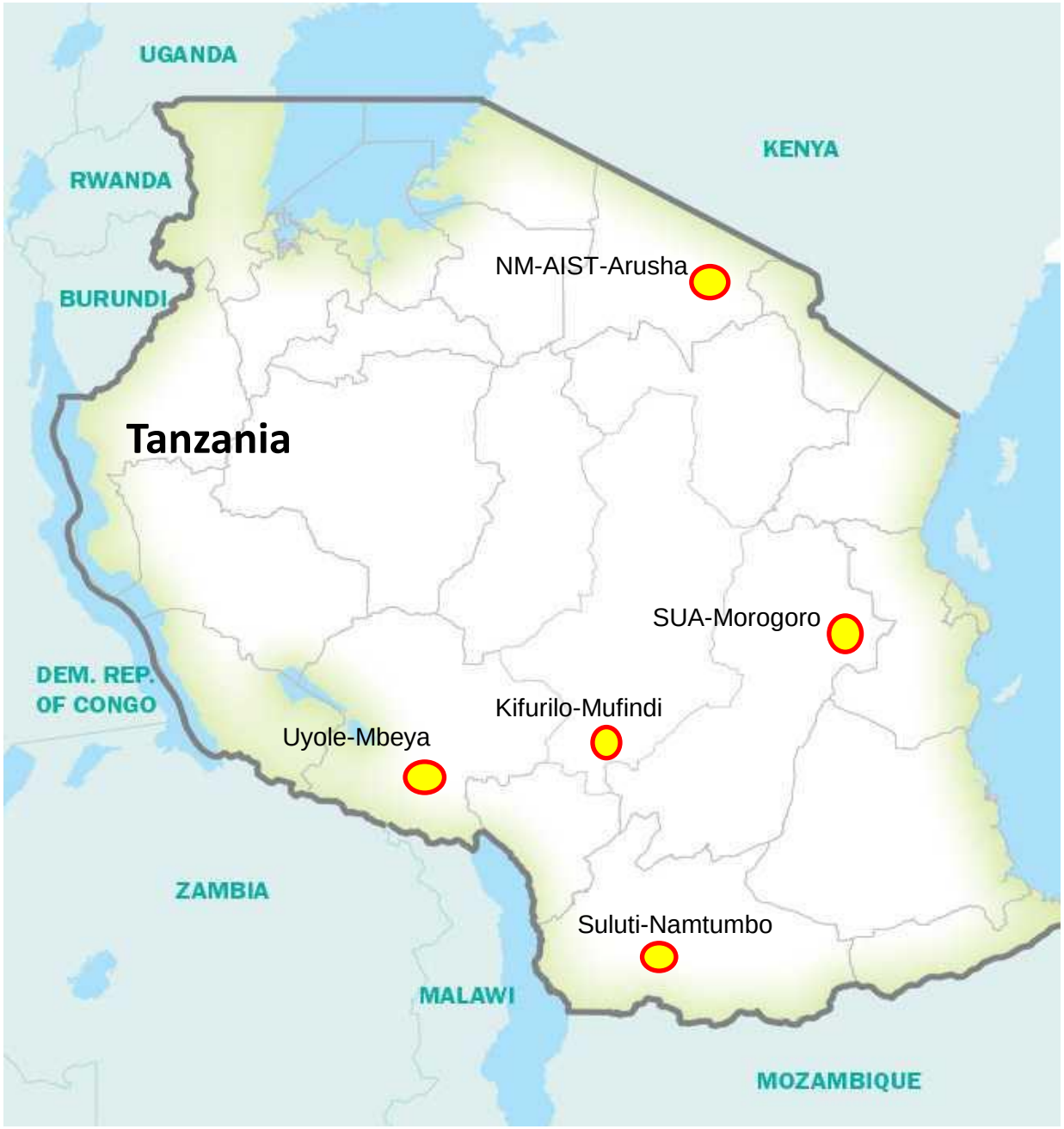
ii. To develop F2 populations of common bean lines by crossing widely consumed yellow bean varieties with high and stable seed Fe and low PA genotypes, selected in objective (i).

Research Approach

Materials

- 15 common beans genotypes collected from 2 released yellow beans, 10 local and 3 exotic yellow bean genotypes will be used

Trial sites


UGANDA
KENYA
RWANDA
NM-AIST-Arusha
BURUNDI
Tanzania
SUA-Morogoro
DEM. REP.
OF CONGO
Kifurilo-Mufindi
Uyole-Mbeya
ZAMBIA
Suluti-Namtumbo
MALAWI
MOZAMBIQUE

Materials and Methods: Trial sites description

Particular	Site (Environment)				
Site	**NM-AIST**	**SUA**	**Kifyulilo**	**TARI-Uyole**	**Suluti**
Altitude (m.a.s.l)	1400	540	2000	1770	844
Temperature (°C)	14 – 26	18 – 30	≤ 15	9 – 25	15 – 25
Rainfall (mm)	250 – 1200	500 – 2200	1000 – 1500	650 – 2600	800 – 1200

Materials and Methods: Experimental Design

Design	**RCBD**
Blocks	**3**
Plots/block	**15**
Spacing	**50 x 10 cm**
Rows	**4 row, each 2 m long**

Block I	**PlotNo**	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
	Plots	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Genotype	G4	G9	G13	G6	G7	G12	G10	G3	G5	G8	G14	G2	G11	G15	G1
Block II	**PlotNo**	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215
	Plots	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Genotype	G4	G10	G9	G6	G11	G14	G5	G8	G13	G7	G1	G2	G3	G12	G15
Block III	**PlotNo**	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315
	Plots	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Genotype	G7	G10	G11	G13	G8	G9	G12	G15	G2	G5	G3	G4	G1	G14	G6

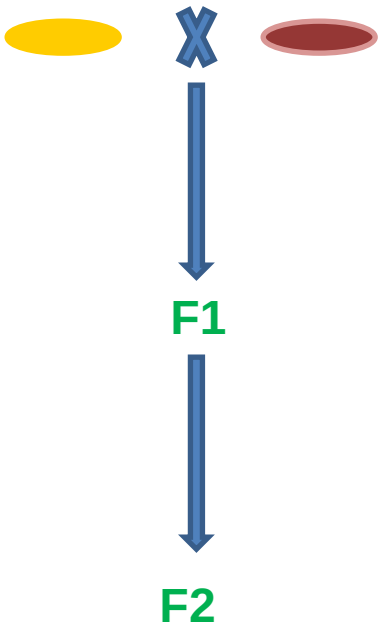
Materials and Methods: Data Collection

- **Objective (I)**
  - To determine the levels of Fe, PA, and yield of common bean genotypes in five bean growing areas of Tanzania
    - **Days to 75 % flowering**
    - **Number of pods per plant**
    - **Number of seeds per pod**
    - **100 seed weight (g)**
    - **Seed yield (kg/ha)**
    - **Seed Fe will be determined using AAS method** (Estefan *et al.,* 2013)
    - **Seed PA will be determined using Megazyme method** (Megazyme, 2017)

Materials and Methods: Data Collection

- **Objective (II)**
  - Development of **F2** crosses
    - Yellow bean varieties (**Selian 13** and **Njano Uyole**) will be crossed with high seed iron and low PA-containing bean genotypes

Low seed Fe & high PA



High seed Fe & low PA)

Materials and Methods: Data Analysis

- ANOVA on days to 75 % flowering, yield, and yield components, seed Fe, and PA contents will performed to determine the differences among the tested genotypes
- Means will be separated using DMRT methods at a 5%
- AMMI ANOVA will be used to determine the effect of G, E, and GxE on yield, Fe, PA, and PA:Fe molar ratio using GenStat statistical
- AMMI and GGE-biplots analysis using PBTools will be used to visualize adaptable, stable and high yielding, Fe and low PA-containing bean genotypes across experimental sites

Acknowledgement

Kirkhouse Trust

Supporting research and education in the biological sciences

Thanks

Asanteni