Lomonosov Moscow State University
ECFS Eurasian Center for Food Security

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

Food Security, Soil and Climate Smart Agriculture Conference
"World Soil Day Celebration"

Improving soil health, food security, and livelihood of smallholder farmers in Mozambique through development and use of appropriate fertilizer blends

UNIVERSIDADE EDUARDO MONDLANE

Rogério Borguete Alves Rafael, PhD

Assistant Professor & Head of Soil Science Division,

Faculty of Agronomy and Forestry Engineering

Sochi, 5-6th December 2019

Structure of presentation

1. Statement of the problem
2. Strategy to solve the problem
3. Preliminary results
4. Final Consideration

1. Statement of the problem

- **799,380 km²**
- **~27,284,701 inhabitants (at Dec 2014).**
- **Poverty is concentrated in rural areas**

1. Statement of the problem

- The **itinerant agriculture system**, without the use of inputs such as irrigation and fertilizers in Mozambique (Benson et al., 2012; Cungura et al., 2013) led to a very low productivity of food security crops;

1. Statement of the problem

- Agriculture challenges
  - **Low use of fertilizers**
  - Lack of input markets
  - Lack of farmers knowledge
  - **Higher price of fertilizers and other inputs**
  - Limited access to extension services

1. Statement of the problem

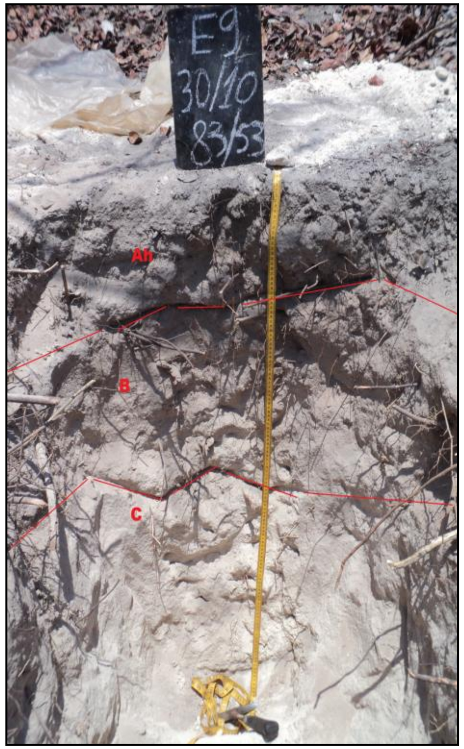
- Fertilizer rate per ha ~ 3kg/ha for food crops (corn, beans etc.)(Benson *et al.*, 2012);
- Almost all imported fertilizer are used for tobbaco and sugar cane (Benson *et al.*, 2012; IFDC, 2011);
- Absence of fertilizer law and only is the fertilizer regulation (being updated)

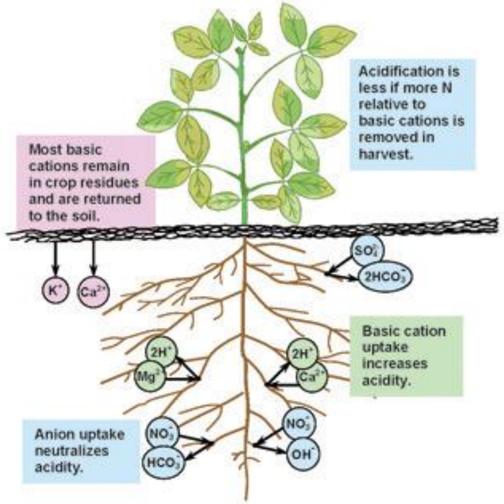
ETG-ADUBOS

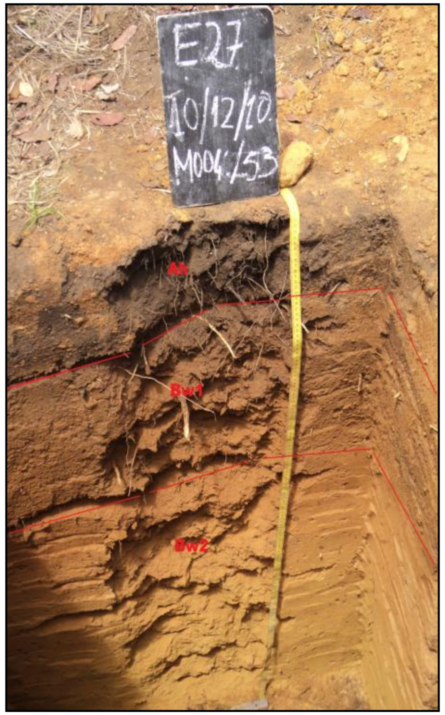
	Fertilizers Price List							
Product name	Composition							
	N	P	K	ZN	NPK	S	B	Cu
Urea								
Npk 23:21:0 +4S	23.00	21.00	0.00			4.00		
Map	11.0	22.0	0.00	0.8%	33.00%			
Npk 12:24:12	12.00	22.0	12.00					
3.2.1. (38) + 0.5% Zn	19.2	12.8	6.4	0.5%	38.38%			
1.1.1. (39)+0.5%Zn	13.0	13.0	13.0	0.5%	39.00%			
1.1.1. (38) + 2.0%Zn	12.5	12.5	12.5	2.0%	37.50%			
1.1.1. (33) +0.5%Zn+6.2%S+0.2%B	10.8	10.8	10.8	0.5%	32.50%	6.20%	0.20%	
1.1.1. (38) + 0.5 %Zn+0.13%Cu+0.25%B	12.7	12.7	12.7	0.5%	38.00%		0.25%	0.13%
KYNOPLUS UREA	46.0	0.0	0.0	0.0%	46.00%			
KYNOPOP	14.3	8.7	4.2	2.4%	27.20%			
MILEIE OEMFF (Maize Foliar fert)								
Foliar Fertilizer (Vegetables &Horticulture)								
VIGGIE OEMFF START								
VIGGIE OEMFF FRUIT								
VIGGIE OEMFF GRO								
CALCIUM NITRATE WS	15.5				15.50%			
POTASSIUM CHLORIDE FINES			50.0		50.00%			
CALCIBOR 50KG	15.4				15.40%			
CALCIBOR 1200KG	15.4				15.40%			
GREENGOLD 30	30.0				30.00%			
NPK	14	28	14		56%			

1. Statement of the problem

- ❑Soil fertility restoration must be the starting point to reverse both the current trend of pressure on land and soil degradation (Bekunda et al., 2002; Van Straaten, 2006; Van Raij, 2011)



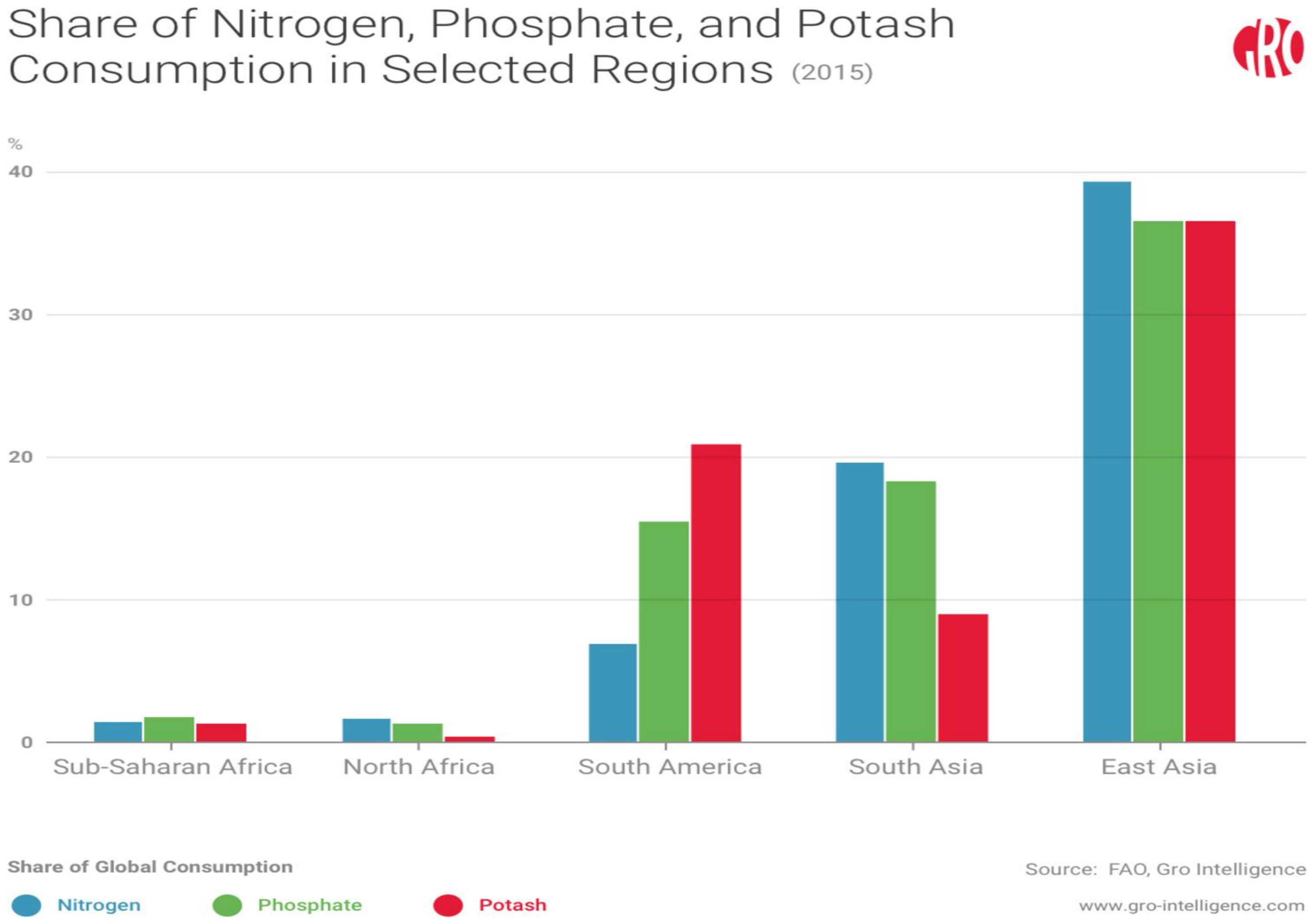




- ❑N, P, and K inputs are required for optimum plant growth in these soils
- ❑Organic amendments are alternative to optimize the fertilizer use

1. Statement of the problem

Focus on mineral fertilizer



1. Statement of the problem

Focus on mineral fertilizer/*Adding nutrients: The 'Green Revolution'*

- A success in Asia and Latin America
  - External input use (mineral fertilizers & lime)
  - Improved varieties
  - Irrigation
- A disappointment in sub-Saharan Africa
  - Fertilizer is 'too costly'
  - Fertilizer use is uneconomic in poorly responsive environments
  - Fertilizer recommendations were not tailored to farmer's specific circumstances
    - Heterogeneous soil fertility
    - The farmer's social and economic situation and goals

1. Statement of the problem

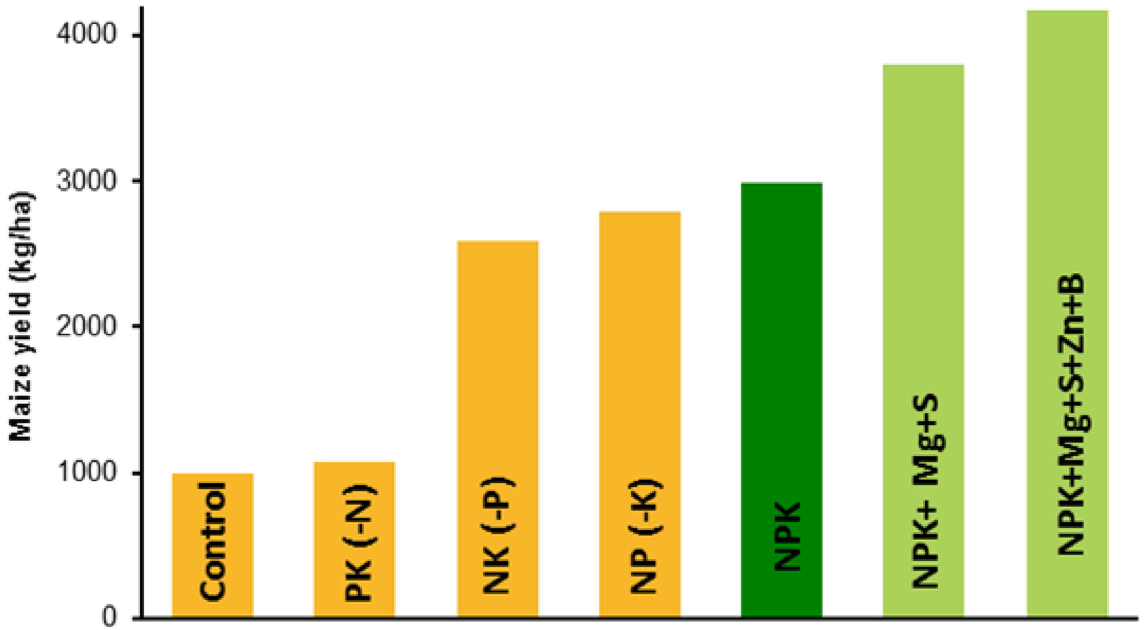
Implication on food security

- Mozambique has been suffering from food insecurity and chronic poverty
  - ✓"The first strategic objective defined under this priority is to **increase the productivity of staple crops** in order to increase food security and access to markets by farmers through access of improved inputs and technologies by smallholder farmers "
- Recent data from on station and on farm trials along the Beira Corridor in Central Mozambique, show maize and legume yields between **1.2 and 0.45 ton/ha, respectively** (IIAM-AGRA-Beira corridor baseline report, 2009; Soil Fertility Consortium for southern Africa baseline study report, 2009 and IIAM-AGRA-Tete baseline project, 2012).

2. Strategy to solve the problem

- There is now strong evidence that addition of blended fertilizers in most soils leads to remarkable improvement in maize yields;
- Thus, fertilizers that contain macro-nutrients (N, P and K), secondary nutrients (sulphur (S), calcium (Ca), and magnesium (Mg)), and several important micro-nutrients (zinc (Zn), iron (Fe), molybdenum (Mo)) are now required;
- Moreover, application of lime and secondary macronutrients and have also resulted in increased yields, even though the responses have shown variability across different sites (Kihara et al, 2016);
- This shows a need to develop site-specific fertilizer blends based on soil analysis to get the expected benefits.

Secondary Macronutrients & Micronutrients effect on yield
*40% yield increase over NPK
*Extra 1200 kg/ha (equivalent to addition US$552 per /ha/season
* 3 t/ha increase from control – more than double in net income increase
* For rice in Rwanda- 40% yield increase (1.7 t/ha, added value of U$660/ha)
* 20% increase in Teff in Ethiopia
Source: AGRA database



2. Strategy to solve the problem

- 6 institutions that will be working in coordination to address the fertilizer problem: IIAM, UEM, YARA/Greenbelt, Mozambique Fertilizer Company (MFC) and DINAS;
- Increasing the availability of improved fertilizers through soil sampling, analysis, mapping, formulation and production of new and appropriate blended fertilizers for maize and soybean;
- Validation of the new fertilizer blends
- Improving the availability of quality fertilizer to smallholder farmers by activating the functioning of the Mozambique Fertilizer Quality Control System

- Synthesising information on soil, plant and fertilizer data

Leader: IIAM

Other contributors : UEM

Leader: IIAM;

Other contributors: UEM;

- Targeted soil sampling, analysis and mapping to identify limiting nutrients

- Development of formulas and subsequent production and testing of fertilizer blends for use in trials and demos, including nutrient omission trials

Leaders: UEM and IIAM

Other contributors: YARA/GB and MFC

Leader: IIAM

Others: UEM,

, YARA/GB and MFC

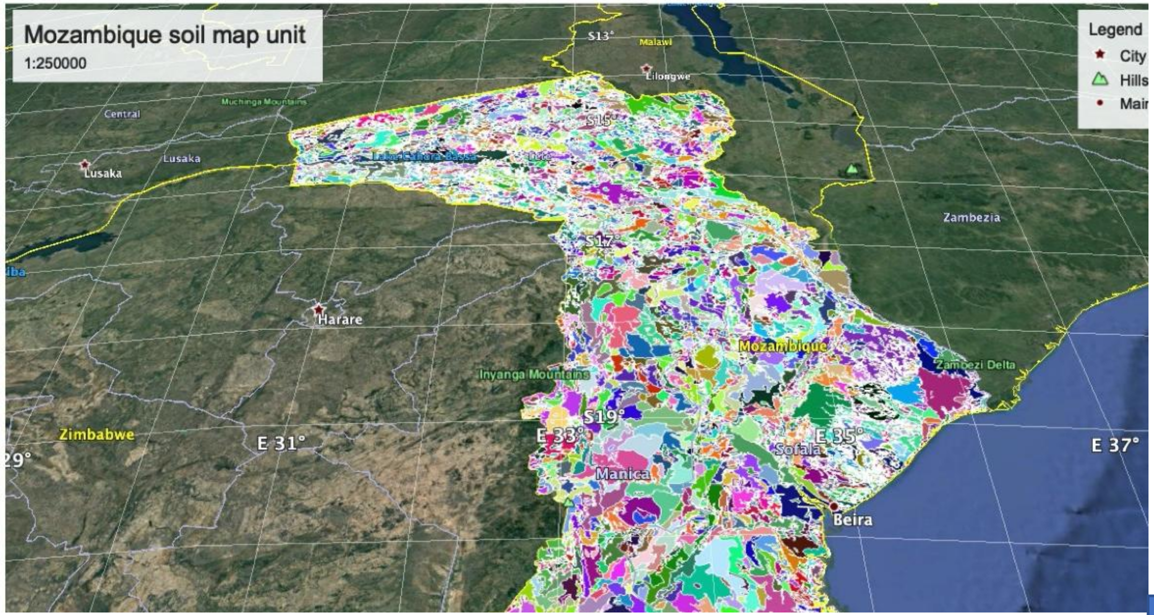
- Validation of new fertilizer blends against existing ones

- Laboratory analysis and registration of new fertilizer blends (including revision and update of fertilizer regulation for easy registration and commercialization of new blends)

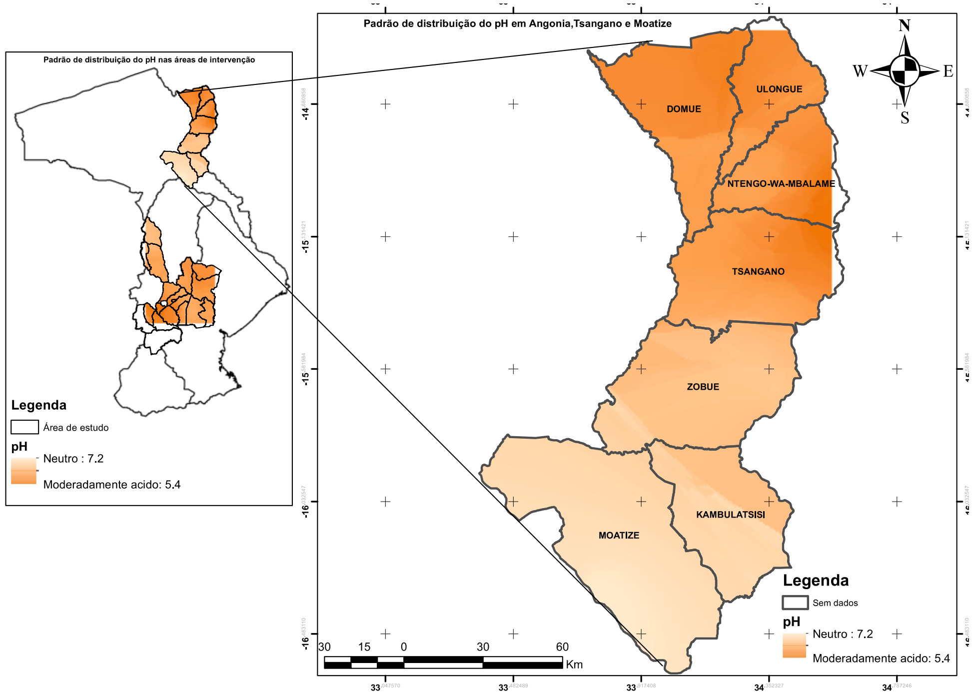
Leader: DINAS

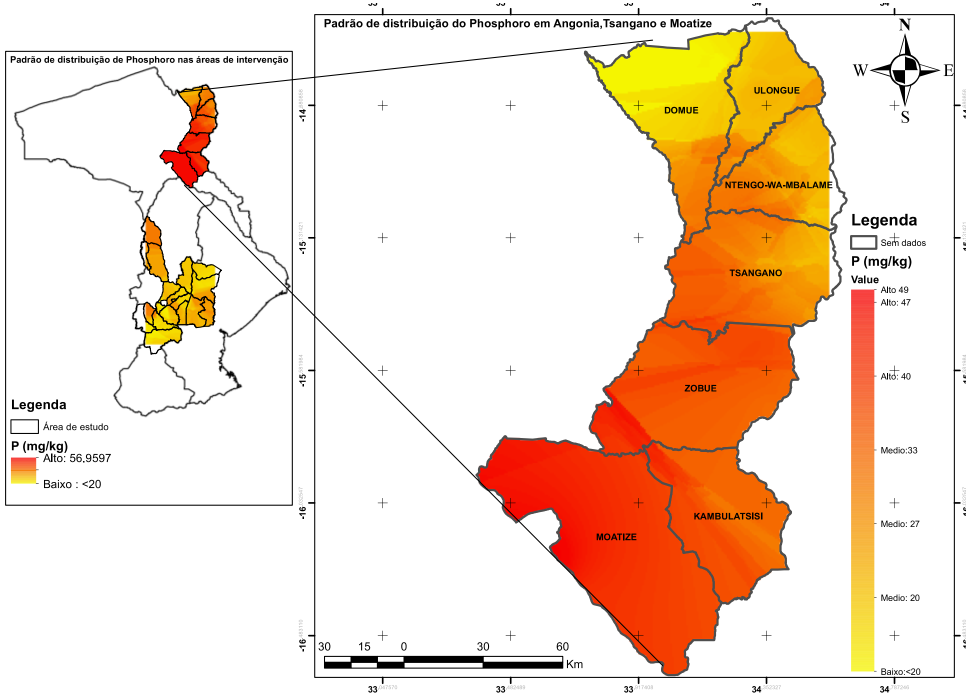
Others: UEM

3. Preliminary results



S. No.	Sample ID	Profile ID	Depth (Cm)	pH (1:2.5 aq)	E.C (1:2.5 aq)	O.M %	Exchangeable Bases (meq/100g)				Acidity (Al + H)	H^+	Al	Total C E C	Texture			Texture Class	P ppm (mg/kg)
					µs/cm	(OCx1.724)	Na	K	Ca	Mg	cmol/kg	cmol/kg	cmol/kg	cmol/kg	Sand %	Silt %	Clay %		
156	MA - 24	CABO 462 M (1)	5 – 15	5.18	34.0	0.36	0.16	0.26	2.40	1.20	0.8	0.8	< 0.1	4.5	87	5	8	Loamy Sand	14.2
157	MA - 24	CABO 462 M (2)	20 - 30	5.12	21.0	0.28	0.17	0.12	2.60	1.40	0.7	0.7	< 0.1	4.8	85	6	9	Loamy Sand	12.6
158	MA - 24	CABO 462 M (4)	55 - 65	5.01	32.0	< 0.02	0.27	0.09	2.80	1.20	0.9	0.9	< 0.1	5.5	78	9	13	Sandy Loam	6.1
159	MA - 24	CABO 462 M (5)	75 - 100	5.35	29.0	0.28	0.19	0.09	3.00	1.00	0.7	0.7	< 0.1	5.1	81	8	11	Sandy Loam	9.8
184	MA - 23	CABO 462 M (3)	35 - 45	6.05	90.0	0.50	0.17	0.16	2.60	1.60	0.6	0.6	< 0.1	4.9	82	8	10	Loamy Sand	22.1
185	MA - 23	CABO 642 B (5)	80 - 95	7.92	280	3.60	0.18	0.73	9.80	3.00	< 0.1	< 0.1	< 0.1	13.4	71	12	17	Sandy Loam	19.2
186	MA - 23	CABO 642 B (6)	105 - 120	8.08	222	2.62	0.16	0.73	11.40	3.80	< 0.1	< 0.1	< 0.1	15.7	68	13	19	Sandy Loam	21.9
187	MA - 23	CABO 642 B (7)	130 - 145	7.96	277	1.04	0.18	0.34	11.60	4.80	< 0.1	< 0.1	< 0.1	16.5	65	15	20	Sandy Loam	32.6
189	MA - 23	CABO 326 B (4)	70 - 90	6.51	57.0	1.28	0.25	0.13	5.40	2.60	0.6	0.6	< 0.1	8.8	74	12	14	Sandy Loam	12.4
211	MA - 15	CAOOO 65 B (1)	0 - 10	8.24	261	0.40	0.80	0.18	11.80	5.00	< 0.1	< 0.1	< 0.1	16.8	58	18	24	ndy Clay Lo	8.5
212	MA - 15	CAOOO 65 B (2)	20 - 25	8.71	565	0.67	3.14	0.09	11.40	5.60	< 0.1	< 0.1	< 0.1	19.8	45	25	30	ndy Clay Lo	9.0
213	MA - 15	CAOOO 65 B (3)	45 - 55	5.82	47.0	1.40	0.23	0.09	3.80	1.40	1.2	1.2	< 0.1	6.8	67	15	18	Sandy Loam	10.3
214	MA - 15	CAOOO 65 B (4)	70 - 85	6.38	33.0	0.83	0.16	0.38	2.80	1.40	0.5	0.5	< 0.1	5.3	65	16	19	Sandy Loam	11.2
215	MA - 15	CAOOO 65 B (5)	100 - 125	5.70	29.0	1.78	0.15	0.12	2.40	1.00	0.6	0.6	< 0.1	4.4	79	9	12	Sandy Loam	9.4
216	MA - 15	CAOOO 65 B (6)	130 - 145	5.52	23.0	1.43	0.14	0.07	2.20	0.80	0.8	0.8	< 0.1	4.1	82	8	10	Sandy Loam	8.6
217	MA - 15	CAOO 377 B (1)	0 - 5	5.53	22.0	0.29	0.14	0.05	1.40	0.60	0.5	0.5	< 0.1	2.8	87	5	8	Loamy Sand	3.2
218	MA - 15	CAOO 377 B (2)	10 – 20	5.98	66.0	1.34	0.15	0.20	3.40	0.80	0.8	0.8	< 0.1	5.5	85	6	9	Loamy Sand	9.7
219	MA - 15	CAOO 377 B (3)	30 - 45	6.15	38.0	0.60	0.33	0.07	3.00	1.20	0.7	0.7	< 0.1	5.4	81	8	11	Sandy Loam	3.2
220	MA - 15	CAOO 439 B (5)	30 - 100	5.01	201	0.76	0.70	0.15	6.00	4.20	2.1	2.1	< 0.1	13.2	49	23	28	ndy Clay Lo	4.9
237	MA - 14	CAQO 439 B (1)	0 - 10	6.75	42.0	0.83	0.15	0.23	3.20	1.20	0.2	0.2	< 0.1	5.1	70	13	17	Sandy Loam	4.9
238	MA - 14	CAQO 439 B (2)	15 - 30	6.93	30.0	1.71	0.16	0.16	2.20	1.60	0.1	0.1	< 0.1	4.2	69	14	17	Sandy Loam	4.4
239	MA - 14	CAQO 439 B (3)	40 - 50	6.63	38.0	0.67	0.15	0.16	2.40	1.40	0.2	0.2	< 0.1	4.4	73	12	15	Sandy Loam	11.7
240	MA - 14	CAQO 439 B (4)	60 - 75	9.08	12.7	0.16	3.86	0.21	9.60	4.80	< 0.1	< 0.1	< 0.1	18.1	59	22	27	ndy Clay Lo	11.2





3. Preliminary results

1	Yara 5-6t Maize programs						84 646 7958 Colin.maxacrop@gmail.com	Maxs-A-Crop
2								
3	Soil	Low	Optimum	High		Preplant	4th leaf	10th leaf
4	pH (KCL)	<5.2				Magflo lime at 10lt per ton lime recommended		
5	Program 2 - Low phosphate and optimum potassium							
6	Phosphate	<20 ppm (Bray)			Basal	Yara 15-30 + 5S + 0.2B + 0.5Zn + 0.2Mn 300 kg/ha 6g/plant		
7	Potassium		>120ppm or > 4% K in CEC		Top 1		Yara 40+6S 100kg/ha 2g/plant	
8					Top 2			Yara 40+6S 100kg/ha 2g/plant
9	Program 3 - Optimum phosphate and optimum potassium							
10	Phosphate		> 20 ppm (Bray)		Basal	Yara 29-10-5 + 5S + 0.2B + 0.5Zn + 0.2Mn 300 kg/ha 6g/plant		
11	Potassium		>120ppm or > 4% K in CEC		Top 1		Yara 40+6S 100kg/ha 1g/plant	
12					Top 2			Yara 40+6S 100kg/ha 1g/plant
13	Folair program							
14	Born	>1ppm			Foliar 1	YaraVita Bortrac 1lt/ha		
15	Zinc	>3ppm			Foliar 1	YaraVita Zinctrac 2lt/ha		
16	Copper	>1ppm			Foliar 1	YaraVita Coptrac 0.5l/ha		
17	Molymdenium				Foliar 1	YaraVita Molytrac 0.4lt/ha		
18					Foliar 2		YaraMila Crop boost 2lt/ha	
19								
20	Soil sampling	Take soil samples 12-8 weeks prior to planting						
21	Leaf Sample	Take leaf sample of cob leaf at emergence of silks						At silking
22								
23	If phosphate levels are below 7 ppm look to broadcast 50kg/ha MAP or TSP, or 100kg/ha SSP to programs 1 and 2							
24	These programs are worked out on a planting density of 50 000 plants/ha							

1	Blends Options (closeset taking into account limitations of blending.																			
2																				
3	#1 - NPK 15-30 + 5S + 0.2B + 0.5Zn + 0.2Mn																			
4		ton	0.300						Transport cost		$0									
5																				
6	Products	%	Raw matterials	N	P2O5	K2O	Mg	Ca	S	B	Zn	Fe	Cu	Mn	Mo	Cl	Humate	Cost	Cost
7	MAP 52	57.7	0.173	6.3	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$655.00	$377.94
8	MOP	8.4	0.025	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	$481.00	$40.40
9	ASG	19.5	0.059	4.1	0.0	0.0	0.0	0.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$379.00	$73.91
10	Urea	9.9	0.030	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$500.00	$49.50
11	Tiger Mn	1.5	0.005	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	$1,335.00	$20.03
12	Boron Gran 14.5	1.5	0.005	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$1,135.00	$17.03
13	Zinc Sulfate 34% Gran	1.5	0.005	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	$1,535.00	$23.03
14																			
15	ton	100.0	0.300	15.0	30.0	5.0	0.0	0.0	5.7	0.2	0.5	0.0	0.0	0.2	0.0	3.4	0.0		$601.82
16																			
17	#2 - NPK 15-30 + 5S + 0.2B + 0.5Zn																		
18		Ton	0.300																
19																			
20	Products	%	Raw matterials	N	P2O5	K2O	Mg	Ca	S	B	Zn	Fe	Cu	Mn	Mo	Cl	Humate	Cost	Cost
21	MAP 52	57.7	0.173	6.3	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$655.00	$377.94
22	MOP	8.4	0.025	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	$481.00	$40.40
23	ASG	22.4	0.067	4.7	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$379.00	$84.90
24	Urea	8.5	0.026	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$500.00	$42.50
25	Boron Gran 14.5	1.5	0.005	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$1,135.00	$17.03
26	Zinc Sulfate 34% Gran	1.5	0.005	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	$1,535.00	$23.03
27																			
28	Ton	100.0	0.300	15.0	30.0	5.0	0.0	0.0	5.6	0.2	0.5	0.0	0.0	0.0	0.0	3.4	0.0		$585.79
29																			
30	#3 - NPK 29-10-5 + 5S + 0.2B + 0.5Zn + 0.2Mn																		
31		Ton	0.300																
32																			
33	Products	%	Raw matterials	N	P2O5	K2O	Mg	Ca	S	B	Zn	Fe	Cu	Mn	Mo	Cl	Humate	Cost	Cost
34	MAP 52	19.3	0.058	2.1	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$655.00	$126.42
35	MOP	8.4	0.025	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	$481.00	$40.40
36	ASG	17.3	0.052	3.6	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$379.00	$65.57
37	Urea	50.5	0.152	23.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$500.00	$252.50
38	Tiger Mn	1.5	0.005	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	$1,335.00	$20.03
39	Zinc Sulfate 34% Gran	1.5	0.005	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	$1,535.00	$23.03
40	Boron Gran 14.5	1.5	0.005	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$1,135.00	$17.03
41																			
42	Ton	100.0	0.300	29.0	10.0	5.0	0.0	0.0	5.2	0.2	0.5	0.0	0.0	0.2	0.0	3.4	0.0		$544.96
43																			
44	#4 - NPK 29-10-5 + 5S + 0.2B + 0.5Zn																		
45		Ton	0.300																
46																			
47	Products	%	Raw matterials	N	P2O5	K2O	Mg	Ca	S	B	Zn	Fe	Cu	Mn	Mo	Cl	Humate	Cost	Cost

3. Preliminary results

Control

T1: 15N-30P-5K+5S+0.2B+0.5Zn+0.2Mn

T2: 15N-30P-5K+5S+0.2B+0.5Zn

T3: 29N-10P-5K+5S+0.2B+5Zn+0.2Mn

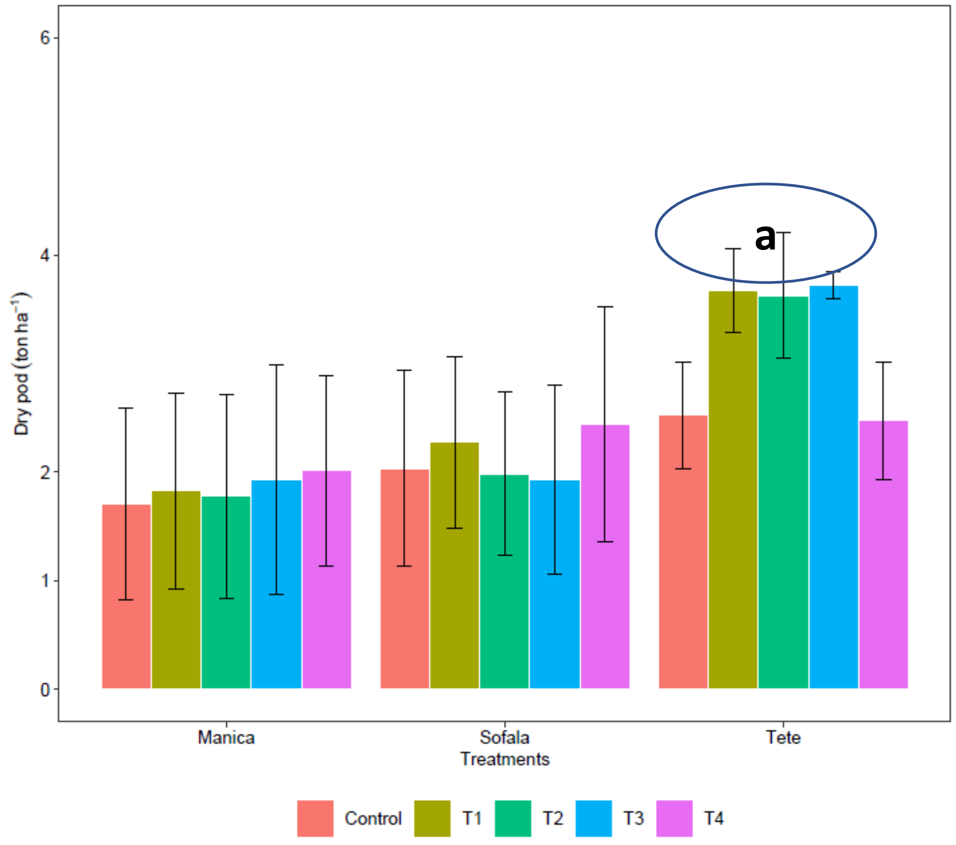
T4: 29N-10P-5K+5S+0.2B+5Zn

T5: 14N-28P-14K

T6: 23N-21P-0K+4S

T7: 12N-24P-12K+2S

3. Preliminary results



- **Control**
- **T1: NPK 5-30-0+9S+0.2B+0.5Zn+0.2Mn**
- **T2: NPK 5-30-0+8.5S+0.2B+0.5Zn**
- **T3: NPK 5-25-0+5S+0.2Mn**
- **T4: NPK 14-28-14**

4.Final Consideration

- **Continue with validation trials**
  - 54 trials planned
  - Inputs (fertilizer and seed) already in place
  - Fields already prepared
- **Introduce lime trials**
  - 6 trials planned
  - Lime already in place and characterized
- **Introduce small packs of fertilizer to farmers**
  - 5000 farmers targeted
  - Best blends (according to preliminary results) to be distributed
  - Farmer identification and registration in course (extension)
- **To carry out a results dissemination workshop**
  - National/regional level
  - To include relevant actors
- **Train other stakeholders**
  - Extension staff, VBA's, Farmers and other technicians
- **Produce and distribute extension material**
  - Materials in development (to include preliminary results)

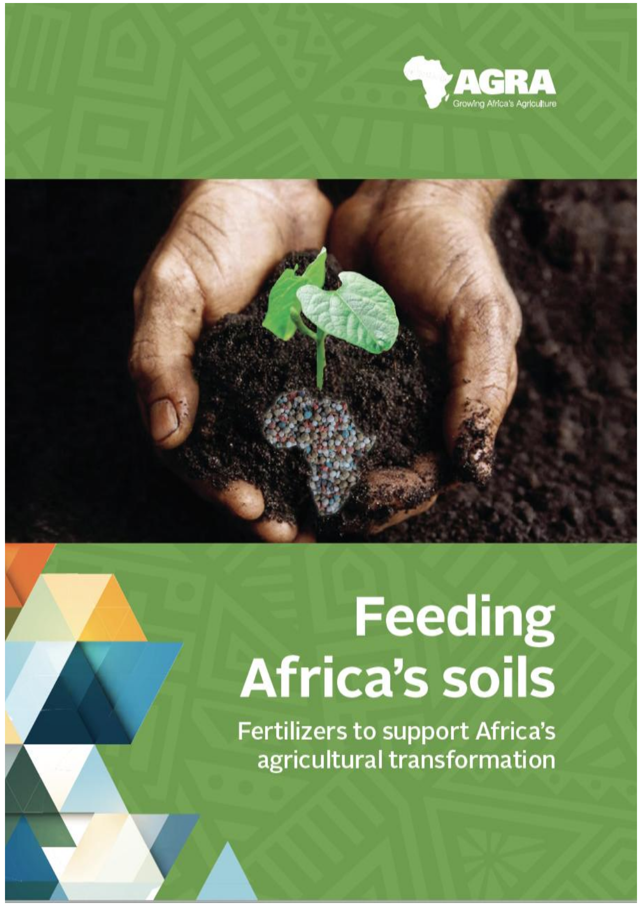
4.Final Consideration

Interesting research questions

- After IDAI cyclone, **what soil changes occurred in Central Areas that need more soil research** to understand what impact it brought to rural population?
- How to improve livelihood and resilience of rural communities affected by cyclone IDAI in center of Mozambique through **sustainable soil management and participative education, contributing to poverty alleviation and resilience**?

4.Final Consideration

https://africafertilizer.org/wp-content/uploads/2019/11/AGRA-Feeding-Africa's-Soils-2019.pdf



RHarawa@agra.org

Dr. Rebbie Harawa

Head of Soil Fertility & Fertilizer Systems

Dr. Rebbie Harawa is currently Head of Soil and Fertilizer Systems with the Alliance for a Green Revolution in Africa (AGRA) responsible for implementing soil health and fertilizer strategy to catalyze an agricultural transformation in Africa. Previously she was Interim Head for Farmer Solutions Program responsible for research and development, and capacity development. Before joining AGRA, Rebbie worked as a Team Leader and Science Coordinator for the UNDP/Columbia University-Millennium Villages Project, a multi-sectoral project which aimed at achieving the Millennium Development Goals (MDG's). Rebbie also worked as an Adjunct Associate Research Scholar (part-time) for Global Health and Economic Development, Columbia University. Previously she also worked for World Agroforestry Center as a Research Specialist where she implemented projects on evaluating agroforestry technologies.

Thank you for your attention

Спасибо за внимание