Improving Rice Productivity through Integrated Soil Fertility and Water Management Practices in Eastern Africa

Tanzania & Uganda

EAAPP Regional Meeting in Morogoro on 27th July, 2015

Team Members

Tanzania

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Uganda

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NOTE: Kenya Researcher passed away: Mr Ogutu

General objective

To enhance productivity of lowland and upland rice ecosystems through appropriate soil, water and nutrient management practices

Specific objectives

1. To identify biophysical, socio-economic and institutional factors contributing to low productivity of rice ecosystems

2. To develop economical integrated soil fertility management options for rice ecosystems

Specific objectives.....

3. To evaluate the agronomic performance and cost-benefits of system of rice intensification (SRI)

4. To establish and/or operationalize innovative alliances for improving famers' knowledge on soil, water and nutrient management practices in rice ecosystems

Project sites

	Tanzania	Uganda
Objective 1	Lake, Eastern Central zones	Namfumba & Naseke
Objective 2	Lake, Eastern Central zones	Namfumba & Naseke
Objective 3	Lake zone	N/A
Objective 4	All project sites	All project sites

Methodological approach

Objective 1:

To identify biophysical, socio-economic and institutional factors contributing to low productivity of rice ecosystems

- **Inception meetings**

- **Diagnostic Survey** – Participatory assessment of important baseline information. **Data gathered**: biophysical, socio-economic and institutional factors contributing to the management of soil fertility in rice production systems.

Methodological approach…

Objective 2: To develop economically integrated soil fertility management options for rice ecosystems

Tanzania Upland rice

Treatments tested

- Industrial mineral fertiliser rates tested

✓N rates 0, 40, 80, 120

✓P rates 0, 15, 30

✓Combination of N and P

✓TOTAL treatments 12(mother trial year 1& 2)

Methodological approach…

Objective 2: Treatments tested…..continue

- Organic + Combination of inorganic + organic
- ✓FYM and slury rates 0, 2.5, 5, 10/ha
- ✓P rates 0, 15, 30
- ✓Combination of FYM and P
- ✓TOTAL treatments 12 (mother trial year 1 & 2)
- **Babies trial: 4 selected treatments from mother year 2)**
- **Demo trials (0.25 – 1 acre) year 3**

Methodological approach…

Objective 2: Treatments tested…..continue

Uganda –Upland

1) Control
2) 5 ton/ha FYM
3) 60 N; 15 P kg/ha; 2.5 ton/ha FYM
4) 60 N; 15 P kg/ga
5) 60N; 15 P ; 60 K kg/ga

Methodological approach…

Objective 2: Treatments tested

Tanzania – Lowland Rainfed

1) 20 kg P/ha (DAP) + 40 kg N/ha (urea)
2) 40 kg N/ha (urea) + 20 kg P Minjingu mazao
3) 40 kg N/ha (Urea) ; 20 P kg/ha (TSP)
4) 5 ton/ha FYM + 40 kg N /ha (urea)
5) Control- No fert.

Tanzania Lowland Irrigated

1) Minjingu Mazao (20 kg /ha^{-}) + Urea 40 kg N /ha T1
2) urea at 60 kg N /ha+ 20 kg P /ha (MHP)- T2
3) FYM (5 ton /ha) + urea 40 kg N /ha T3
4) DAP (20 kg P /ha) + Urea at 60 kg N /ha T4
5) urea at 40 kg N /ha + 20 kg P /ha DAP T5
6) Farmers practice (i.e. No fertilizer applied) T6

Methodological approach

Objective 3: To evaluate the agronomic performance and cost-benefits of system of rice intensification (SRI)

Tested in Nyatwali Tanzania

- Three varieties were tested (TXD 85, 88 & SARO 5

- T –test was used to test performance of the three Var against Conversional flooding and SRI
- For Researcher managed Trial water was channeled by using pump

Methodological approach

Major difference between SRI and Conversional flooding

Conversional Flooding	SRI
Transplanted at 21-30 days	Transplanted at 8-14 days
Transplanted 2-3 seedling s	Single seedling is transplanted
Continuous flooding	Wetting and drying
Use 20 X 20 spacing	25 X 25 spacing

Methodological approach …

Objective 4: *To establish and/or operationalize innovative alliances for improving famers' knowledge on soil, water and nutrient management practices in rice ecosystems*

- *Undertake training need assessment*
- *Conduct training based on the finding of the training needs, Field days*
- *Produce communication products*
- *Strengthening water users organizations*

RESULTS AND DISCUSSION

Objective 1:

Biophysical, Socio economic and institutional factors which contribute to low rice production

Biophysical factors

Soils: Low soil fertility status: N, P, K, OC, Zn

Topography: Undulating to mountainous areas: soil erosion (e.g. Morogoro Rural, Muheza, Ulanga)

Climate : Farmers (**57.0 -72.8%**) *realised that, there is a* prolonged drought and unreliable rainfall

RESULTS AND DISCUSSION

Objective 1: Fertility status of the soils in the study areas under upland rice

Soil Properties	Range & Average	Fertility status
pH	5.0 – 8.1 Average with STDev (5.78 ± 0.4)	29% - strong to strong acidity 64% - had medium acidity 9% - saline soil (pH 8.1)
OC	*0.6 – 1.5* (1.11 ± 0.4)	57% - have low OC 43% - medium levels of OC
Total N	0.01 – 0.4 (0.14 ± 0.1)	71% - low (indicating nitrogen deficiency for crop production.
Extractable P (Bray & Olsen)	0.8 – 39 (7.96 ± 10.3)	71% - Low P

Findings – Objective 1 ..UGANDA

Soil status

	Namfumba	Naseke	Critical Value
pH	5.7	6.0	5.2
OM %	3.4	3.4	3.0
P (ppm)	4.3	Trace	5.0
K (ppm)	312	304	150
Ca (ppm)	2217	2736	350
Mg(ppm)	378	476	100
	Sandy loam, clay loam to sandy clay loam	Sandy loam to sandy clay loam	

Social economic factors

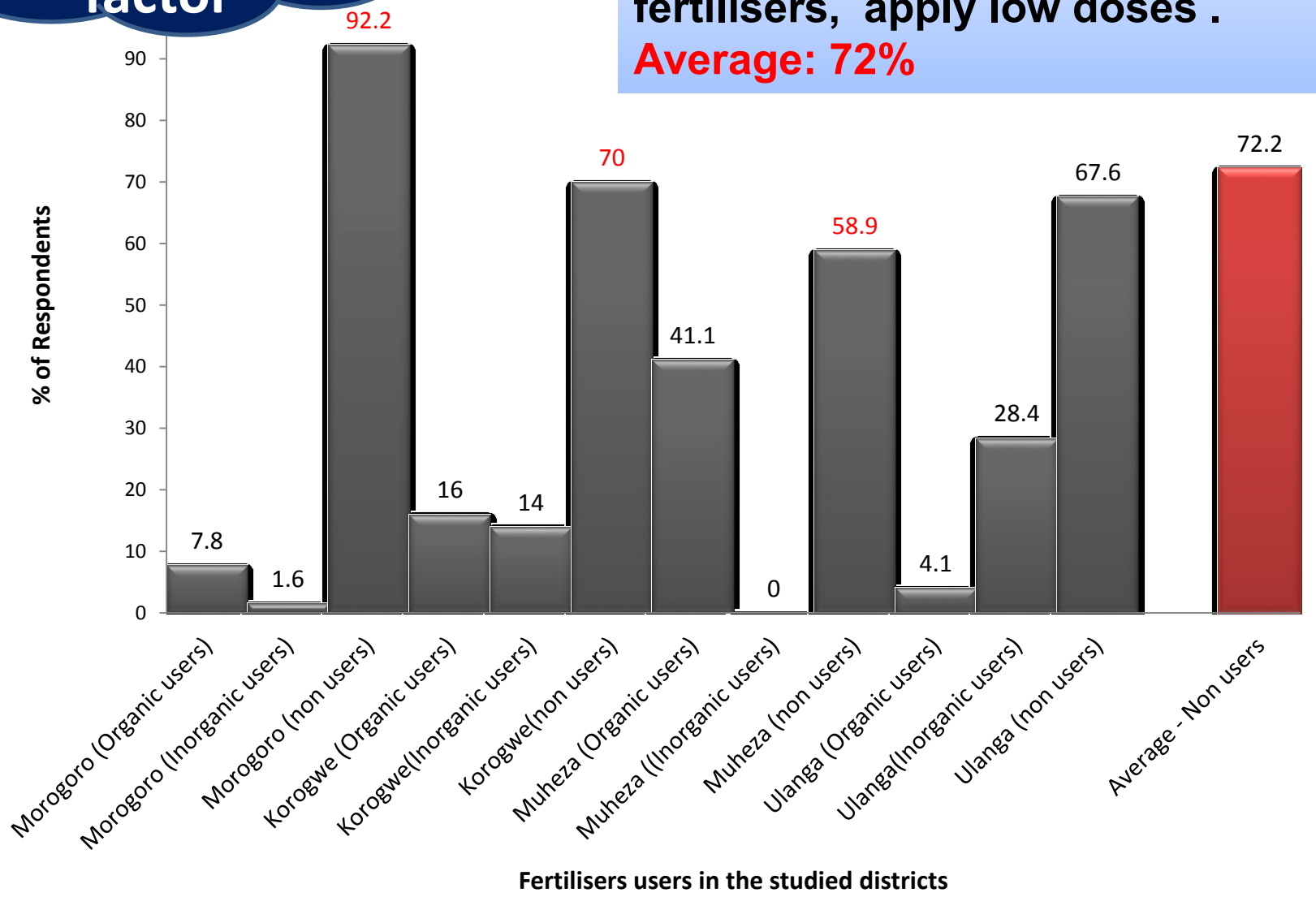
- **Limited financial resource**

69% to 86% of the farmers (in the 4 studied districts) have limited financial resources (resource poor farmers). Overall average: 74.3%

- **Use of local and low yielding rice varieties** *(range: 44 – 90%; Average:* 78% *)*

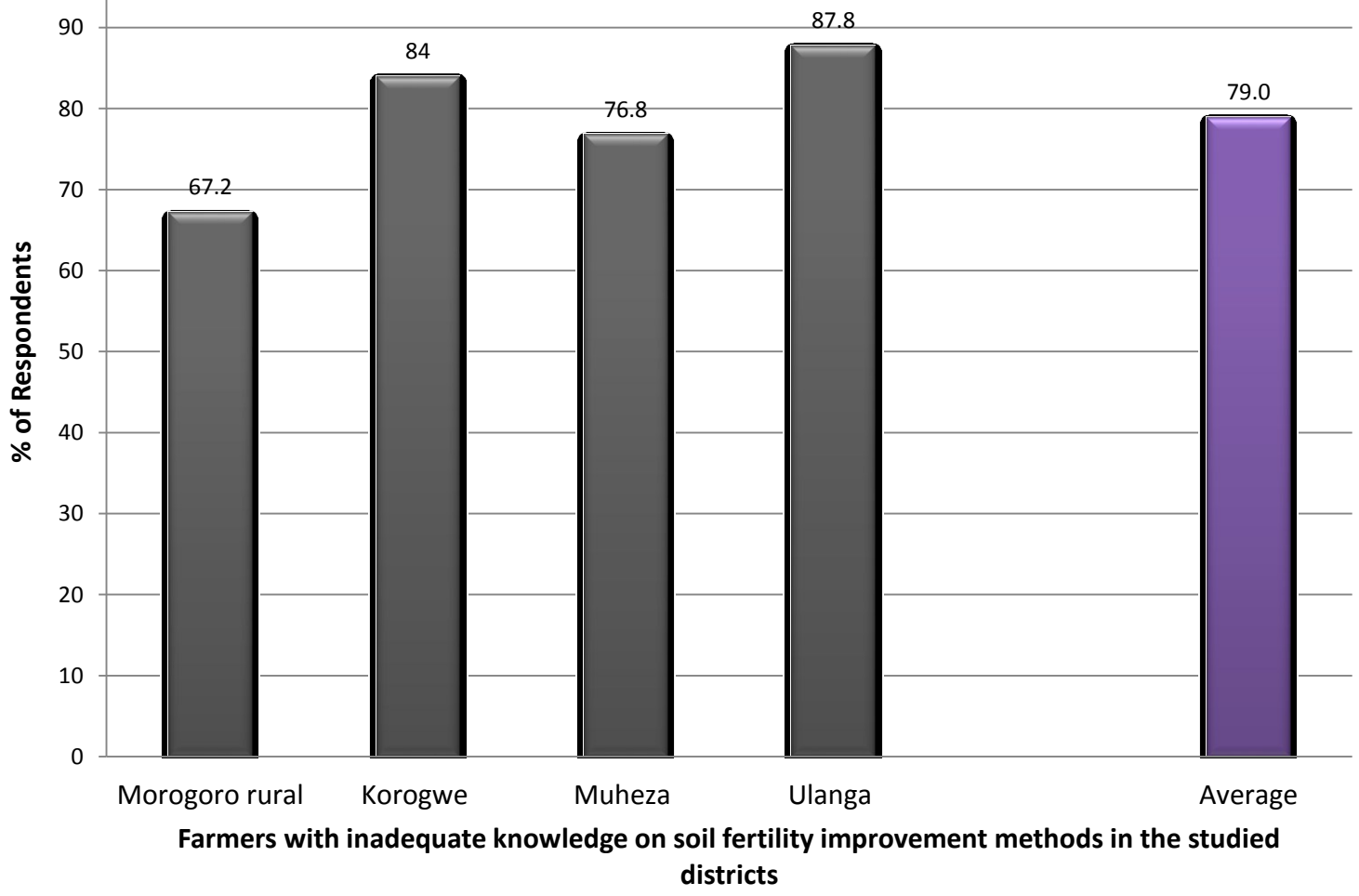
Social economic factor

Most farmers do not apply fertilisers (58.9 – 92.21%) to improve soil fertility, and those who applying fertilisers, apply low doses . Average: 72%



Social economic factor

67%– 89%) of the farmers have inadequate knowledge on soil fertility management, soil and water conservation measures



Institutional factors

Marketing

- few farmers (23.2-47.3%) from the study area experience marketing problems for rice

Extension services

- 36 to 57% of the farmers reported that there are few extension officers
- 27 – 47% of the farmers reported that they don't get advice from extension officers

Findings – Objective 2

To develop economically integrated soil fertility management options for rice ecosystems

Tanzania Upland

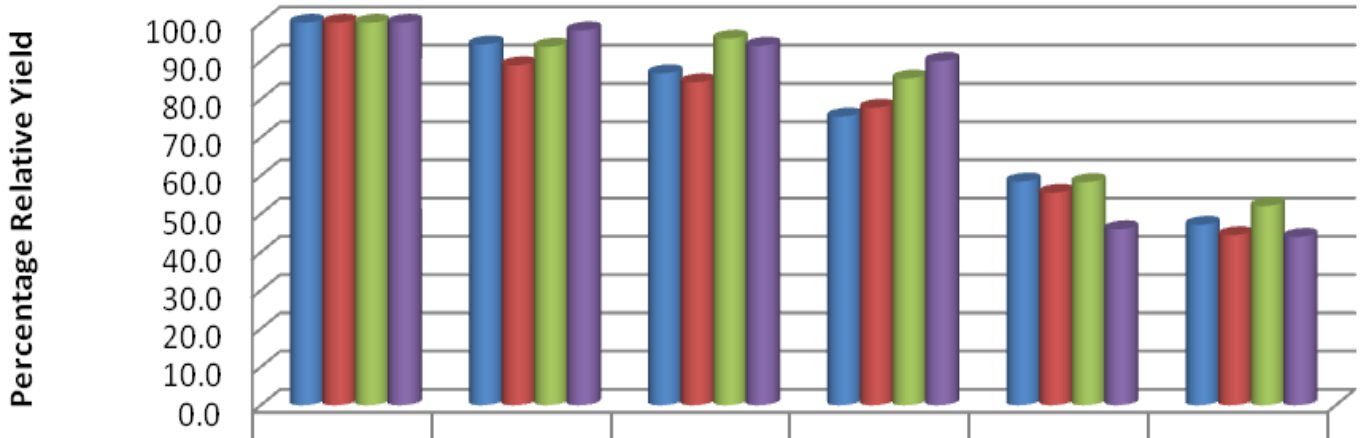
Findings – Objective 2

Response of upland rice (NERICA 1) to applied N, P and K fertilisers in the study areas

Treatments	Masimba	Kwemsala	Mnyuzi	Lusanga
$N_{60}P_{20}K_{33.5}$	5.3^{a}	4.5^{a}	4.8^{a}	5.0^{a}
$N_{60}P_{20}$	5.0^{ab}	4.0^{b}	4.5^{ab}	4.9^{a}
$N_{60}K_{33.5}$	4.6^{b}	3.8^{bc}	4.6^{ab}	4.7^{ab}
N_{60}	4.0^{c}	3.5^{c}	4.1^{b}	4.5^{b}
$P_{20}K_{33.5}$	3.1^{d}	2.5^{d}	2.8^{c}	2.3^{c}
Control (No fertilisers)	2.5^{e}	2.0^{e}	2.5^{cd}	2.2^{c}
(CV %)	14.3%	17.1%	10.6%	12.5%

Findings – Objective 2

Percentage relative rice yields from the treatments receiving one or more nutrient relative to yield of treatment with all nutrients (NPK).



	NPK (all added nutrients)	NP (without K)	NK (without P)	N (without PK)	PK (without N)	Control (No fertilisers)
Masimba (E2)	100.0	94.3	86.8	75.5	58.5	47.2
Kwemsala (E6)	100.0	88.9	84.4	77.8	55.6	44.4
Mnyuzi (E3)	100.0	93.8	95.8	85.4	58.3	52.1
Lusanga (E3)	100.0	98.0	94.0	90.0	46.0	44.0

Year	Fertiliser treatments tested	Yield from the controls and the selected treatments by farmers	Yield increase (%) from the control treatment
2013	**(i) 12 treatments (mother trial)**: Nirogen (N), phosphorus (P), farm yard manure (FYM) and their combinations (Appendix 1) **(ii) Four treatments were selected by farmers** • N_{40} kg/ha + $FYM_{2.5}$ t/ha + P_{15} kg/ha • $N_{80} + P_{30}$ kg/ha • N_{80} + P_{15} kg/ha • FYM_5 t/ha + P_{15} kg/ha	**-Upland rice grain yields:** Control s: mean 2.5 ± 0.19 t/ha Yield range for selected treatments (outlined in ii): 5.43 - 5.77t/ha Mean: 5.16 ± 0.21 t/ha Economic analysis: (Appendix 2a) **-Cowpea grain yields:** Control mean: 0.64± 0.09 t/ha Yield range for selected treatments: 1.2 -1.7 t/ha Mean: 1.58 ± 0.21 t/ha Economic analysis: (Appendix 2b)	117 – 131% There was significant difference among treatments ($P<0.05$) 104 – 166% ($P<0.05$)

2014	**i)Mother trial**: **12 treatments** **ii) Babies trials:** Four selected treatments were tested by farmers • N_{40} kg/ha + $FYM_{2.5}$ t/ha + P_{15} kg/ha • $N_{80} + P_{30}$ kg/ha • N_{80} + P_{15} kg/ha • FYM_5 t/ha + P_{15} kg/ha	**-Upland rice grain yields:** ***Mother trials*** Control s: mean 2.1 ± 0.20 t/ha Yield range for selected treatments: 4.16 - 4.67t/ha Mean: 4.23 ± 0.21 t/ha Economic analysis: (Appendix 2d) ***Babies trials - (4 to 5 famers per treatment):*** Control s: mean 1.87 ± 0.27 t/ha Yield range for selected treatments: 3.51 - 4.01t/ha Mean: 3.7± 0.27 t/ha **-Cowpea grain yields:** ***was not grown due to lack of funds***	98 – 119% There was significant difference among treatment ($P<0.05$) 88 – 114%
2015	34 Demonstration trials were set on farmers fields at Mnyuzi village (15 sites), Masimba village (14 sites) and Kibwaya village (5 sites)	Just harvested	NA

Findings – Objective 2

Tanzania Upland Economic analysis

Year 1 (2012/2013

			Treatments selected by farmers			
Year 1	F/practice	Control	$N_{80} + P_{15}$ kg/ha	N_{40} kg/ha + $FYM_{2.5}$ t/ha + P_{15} kg/ha	FYM_5 t/ha + P_{15} kg/ha	$N_{80} + P_{30}$ kg/ha
Yield (t ha^{-1})	0.56	2.48	5.44	5.78	5.62	5.66
Gross Benefit per ha (Shs ha^{-1})	1050000	1860000	4080000	4335000	4215000	4245000
Variable costs /ha	630,000.0	630,000.0	1,200,000.0	1,050,000.0	945,000.0	1,325,000.0
Net benefit (Shs per ha)	420,000.0	1,230,000.0	2,880,000.0	3,285,000.0	3,270,000.0	2,920,000.0
B/C ratio	0.7	2.0	2.4	3.1	3.5	2.2

Findings – Objective 2

Tanzania Upland Economic analysis (Year 2)

Items	Control	Treatments selected by farmers	
		N80 + P15 kg/ha	40 N + 2.5 t FYM + 15 kgP /ha
Number of bags per acre (each aprox. 80 kg)	10	20.8	23
Yield (t ha-1)	2	4.16	4.6
Price of 1 bag (upland rice grain)	60000	60000	60000
Gross Benefit per ha (Shs ha-1)	1500000	3120000	3450000
Variable costs /ha	630000	1200000	1050000
Net benefit (Shs per ha)	870000	1920000	2400000
B/C ratio	1.4	1.6	2.3

Cowpea planted on contour strips (between contour ridges) at Kibwaya site in Morogoro Rural district. (photo taken in November 2013)

Morogoro Rural district. (photo taken in November 2013)

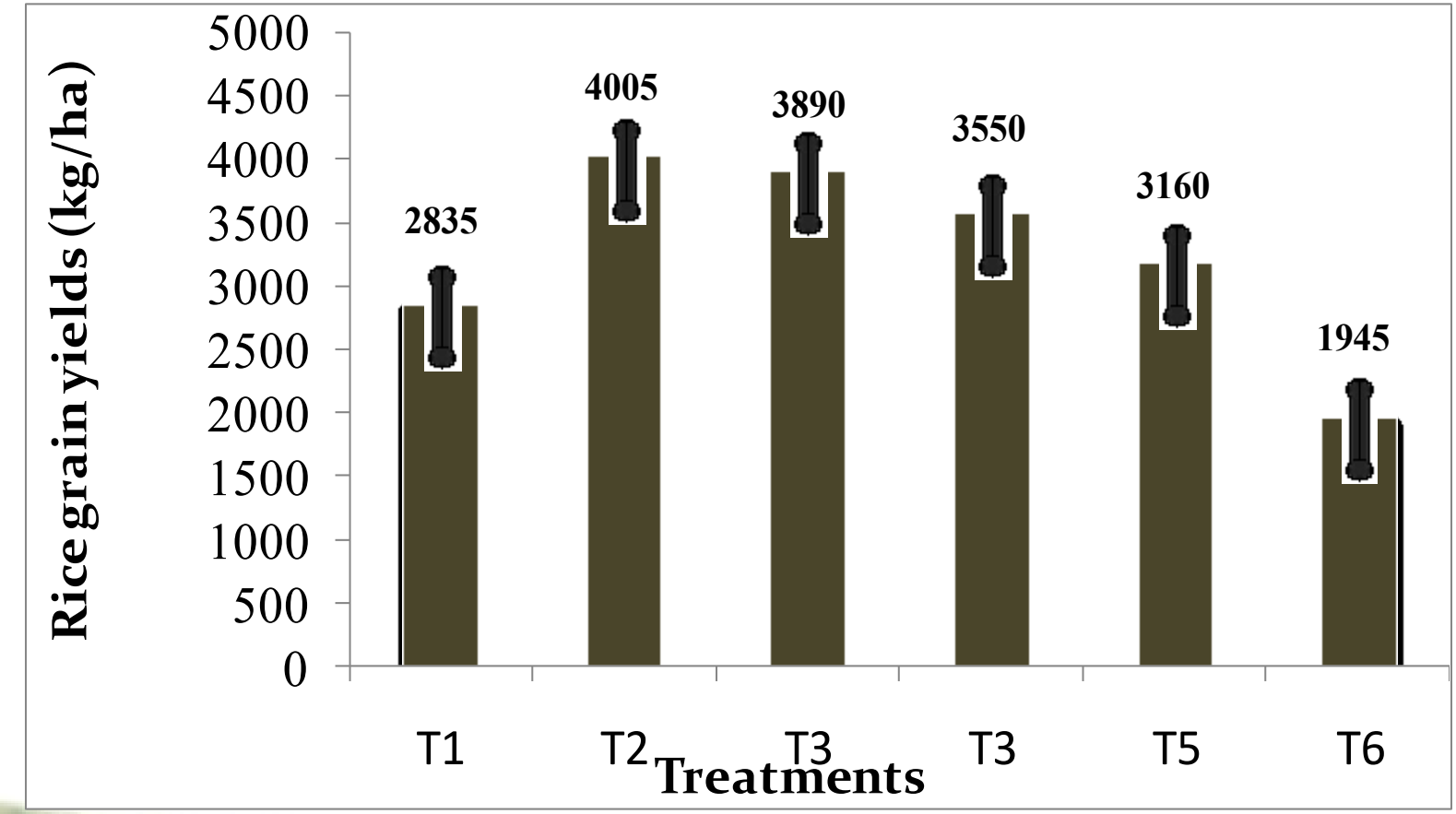
Findings – Objective 2.....

Tanzania Lowland Rice Rainfed (Mean of two ears)

Treatments	Plant height (cm)	No Tillers	Yield (kg/ha)
Use of DAP (20 kg P ha^{-1}) + Urea at 40 kg N ha^{-1}	74.65a	7.12 ab	3020 b
Use of Minjingu mazao (20 kg P ha^{-1}) + Urea at 40 kg N ha^{-1}	73.85 a	8.85 a	3630 ab
Use of urea at 40 kg N ha^{-1} + 20 kg P ha^{-1} as TSP	68.5 b	6.45 b	2335 ab
use of FYM (5 ton ha^{-1} + urea at 40 kg N ha^{-1}	71.65 ab	6.97 ab	2565 b
None Farmers practice	62.15 c	6.57b	2320 b
CV%	2.49	18.26	15.05
LSD	6.407	2.0	520.42

Findings – Objective 2.....

Tanzania Irrigated (Mean of two years)



UGANDA RESULTS Objective 2 Upland

Treatment	Unmilled Yield (t ha^{-1})				
	District and Season				Mean
	2013A		2013B		
	Namutumba	Nakasek e	Namutumba	Nakaseke	
Control	2.33^{c}	1.92^{c}	0.76^{e}	1.92^{c}	1.38d
Manure 5 t/ha	3.32^{b}	2.52^{b}	1.45^{d}	2.52^{b}	2.18c
(30kg N +7.5kg P +2.5 t manure)/ha	3.42^{a}	2.82^{ab}	1.96^{c}	2.82^{ab}	2.85b
(60 kg N + 15 kg P)/ha	3.49^{a}	3.00^{a}	2.32^{b}	2.99^{a}	2.92b
(60 kg + 15 kg P + 60 kg K)/ha	3.57^{a}	2.97^{ab}	2.84^{a}	2.97^{ab}	3.45a

UGANDA RESULTS Objective 2 Upland B/C analysis

Treatment	Yield	Adj. Yield	G. Field benefit	Total costs that vary	Net Benefit	B/C ratio
	kg/ha		Ug.X	Ug.X	Ug.X/ha	
Control	1,380	1,311	2,622,000	1,078,100	1,543,900	1.43
Manure 5 t/ha	2,180	2,071	4,142,000	1,452,900	2,689,100	1.85
(30kg N +7.5kg P +2.5 t manure)/ha	2,850	2,708	5,415,000	1,573,400	3,841,600	2.44
(60 kg N + 15 kg P)/ha	2,920	2,774	5,548,000	1,748,050	3,799,950	2.17
(60 kg + 15 kg P + 60 kg K)/ha	3,450	3,278	6,555,000	2,122,400	4,432,600	2.09

Findings – Objective 3....

:To evaluate the agronomic performance and cost-benefits of system of rice intensification (SRI)

Mean (Three seasons)Yield performance of SRI as compared to conversional flooding (ton/ha) Researcher managed Trial

	TXD 88	TXD 85	TXD 306
CF	3.2	3.0	3.2
SRI	4.0	3.9	4.4
t-Test	**	**	**

Findings – Objective 3....

:To evaluate the agronomic performance and cost-benefits of system of rice intensification (SRI)

Mean (Two seasons Yield performance of SRI as compared to conversional flooding (ton/ha) Farmer managed Trial

	TXD 88 (N=12)	TXD 85 (N=13)	TXD 306 (N=15)
CF	3.2	3.0	3.2
SRI	4.0	3.9	4.4
t-Test	**	**	**

Findings – Objective 3....

:To evaluate the agronomic performance and cost-benefits of system of rice intensification (SRI)

Water productivity of SRI against conversional flooding (Research managed Trial)			
Production system	*Water used (m^3/ha)*	*Yield (kg/ha)*	*Water productivity (kg/m^3)*
SRI	6142.8	6020	0.98
CF	8773	4562	0.52

Findings – Objective 3....

:To evaluate the agronomic performance and cost-benefits of system of rice intensification (SRI)

Gross margin analysis

Item	CF	SRI	Increase (%)
Yield (kg/ha)	4562.5	6020	31.9
Price (Tsh/kg)	850	850	
Total Revenue (Tsh/ha)	3,878,125	5,117,000	
Total VC	1,214,000	1,450,000	
Gross margin (Tsh/ha)	2,664,125	3,667,000	37.6

Findings – Objective 4....

: *To establish and/or operationalize innovative alliances for improving famers' knowledge on soil, water and nutrient management practices in rice ecosystems*

- *Two registered Water users organizations were formed and strengtherened*

- *Eight research groups were strengthened on ISFM, water management*

- *Communication products produced (Maps 2 Booklets 125 (distributed), Manual 2, papers 2)*

- *Trainings offered on ISFM was offered to 350 farmers (47.5 Male & 52.5 female)*

Conclusions

:Objective 1:

- The most limiting nutrients for upland, rainfed and irrigated rice production in the study areas is N followed by P. Nitrogen deficiency in the study area reduce almost 40 - 50% of the total yields

- Other social economic factors contribute to low crop yield in rice ecosystems

Conclusions

:**Objective 2:**

- Most Soils under rice ecosystems require fertiliser application to optimise yields and sustain production
- Use of the established ISFM technologies is recommended . For example 30 kg N+7.5 kg P + 2.5 ton FYM/ha for upland rice in Uganda
- While in TZ the use N_{40} kg/ha + $FYM_{2.5}$ t/ha + P_{15} kg/ha; N_{80} + P_{15} kg/ha; FYM_5 t/ha + P_{15} kg/ha can be used in the upland rice studied areas
- In irrigated use of N at 60 and 20 kg P plus straw incorporation is recommended. In rainfed use of 20 kg P and 40 kg N is recommended.

Conclusions

✓**Objective 3:**

Technically SRI increase yield by 32 % with productivity of water being 0.98 kg/m^3 of water Vs 0.52 kg/m^3 of CF.

Objective 4:

✓ **Capacity of farmers were strengthened through training, production of communication products, field days**

Achievements

Establishment functional water users association in irrigated rice ecosystem (the case of Nyatwali) with their appropriate committees reduces conflicts among water users hence increase water use efficiency

Achievements

Better agricultural water management increase rice yield from 4.5 to 6.0 ton ha^{-1} in irrigated ecosystem

- Establishment of water users association in irrigated systems with their appropriate committees reduces conf

Achievements

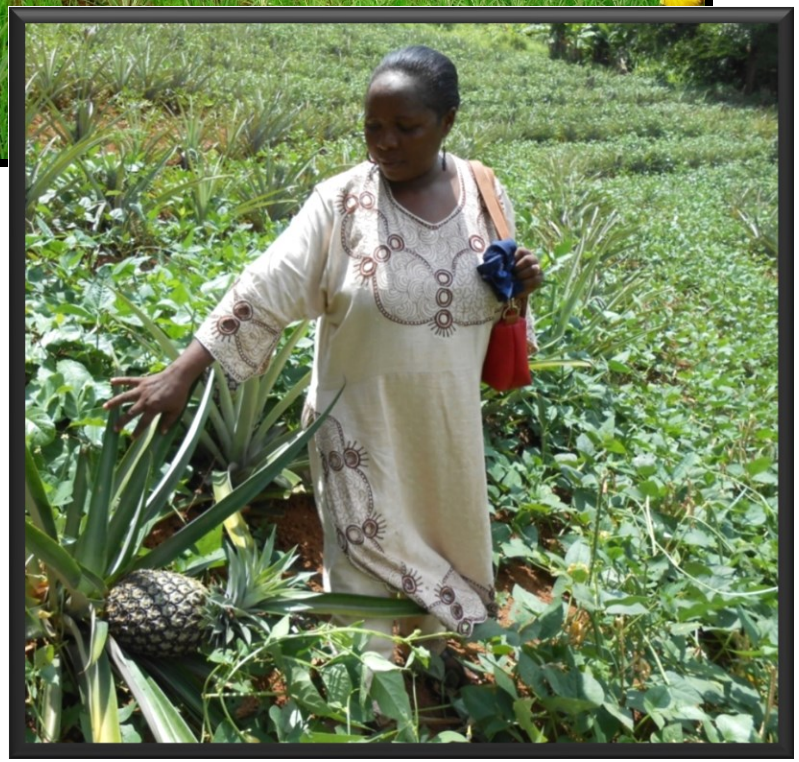
In upland rice ecosystems, Established ISFM technologies increased rice production from 2.5 t/ha to > 5 t/ha

Achievements

- SRI increases yield by 25-37 % with gross margin increase by 37%
- SRI increases productivity of water from 0.5 to 1.0 kg paddy m^3 water

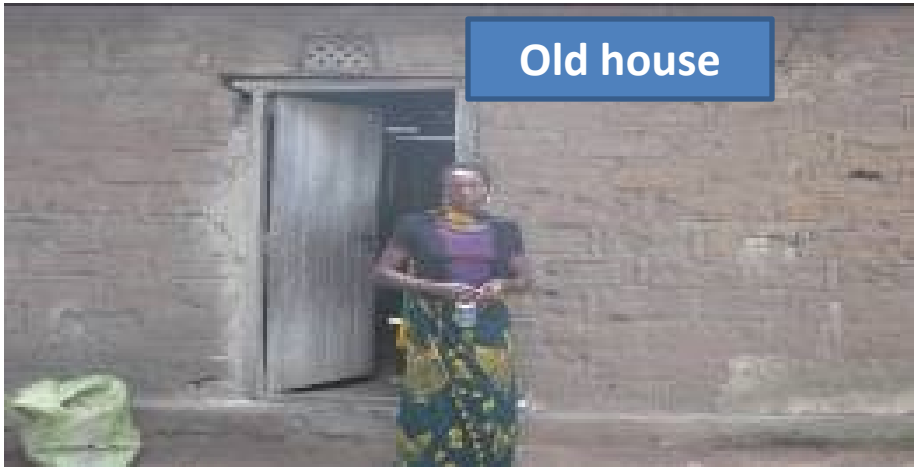
Achievements

- Farmers have better understanding on Integrated Soil Fertility Management (ISFM) which may be used to improve and sustain production in rice ecosystems



Achievements

- Farmers were able to build good houses and establish business enterprises from income accrued from rice farming (The case of Nyatwali)



- Establishment of water users association (WUA) with their appropriate committees reduces conf

Achievements

- ISFM technologies are effective in increasing rice yields and economic returns to the farmers

Uganda

Tanzania

Way forward

✓ Communicate/disseminate the results to a wide audience

✓ Undertake more demonstrations on ISFM and SRI

✓ Conduct study on nutrients dynamics (especially Na) under SRI conditions and different soil types

✓Conduct research to establish economical K rates and micro nutrients (e.g Zn) especially for upland rice)

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- Farmers in the study areas
- Village government officials

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