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Nitrogen budgets and flows in African smallholder farming systems; ORM4Soil and SysCom projects, Kenya

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Introduction

- Declining soil fertility in Africa; low soil nutrient, limited use of soil inputs, nutrient mining
- Nitrogen (N);
  - ➢ most limiting nutrient crop production in smallholder farms in Africa
  - ➢ Responsible for crop growth and yields

Challenges of N balances at farm level in Africa

- N highly susceptibility to; denitrification, Leaching, volatilization, runoff or erosion, overgrazing
- Land degradation; Continuous monocropping, limited land sizes, climate change
- High population; farming marginal lands
- Limited use of mineral fertilizer; access, cost
  - ❖ 18 kg/ha in 2020 nutrients to 54 kg/ha by 2034
  - ❖ NUE to at least 60% to support profitable farming and environmental sustainability
  - ❖ Promote organic agriculture practices to improve soil health (AFSH summit, 2024)

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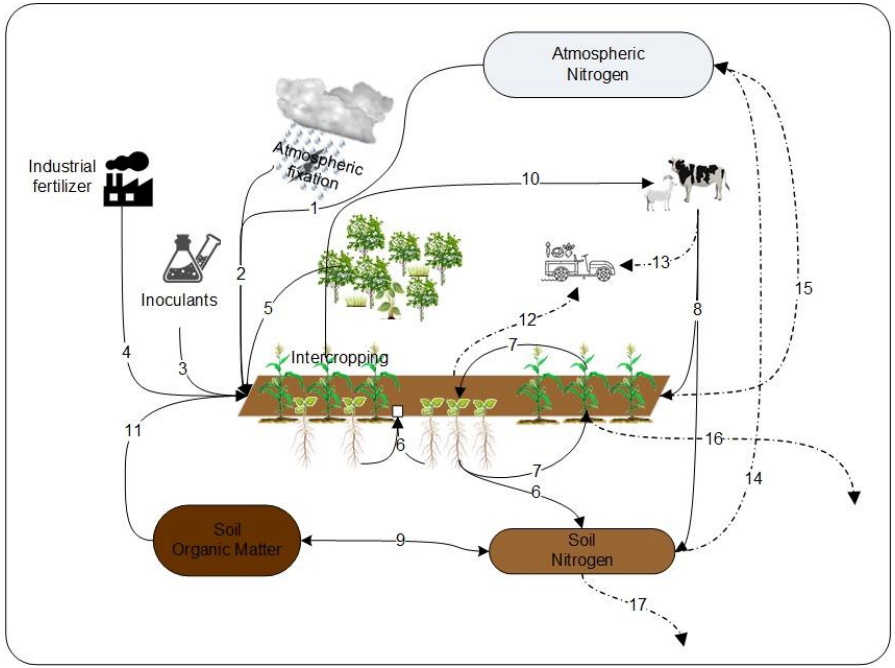
Nitrogen flows and balances at farm level in Africa

Nitrogen Flows	
Inputs	**Output**
Organic inputs (Manures, Composts, Crop residue retention)	Crops harvested
Biomass transfer	Crop residues removal
Biological N fixation (Legume intercrop, Inoculant application	Leaching below the root zone
Mineral fertilizers	Runoff and erosion
Atmospheric N	Gaseous losses- Volatilization, Denitrification



Kiboi et al. (2019) Nitrogen budgets and flows in African smallholder farming systems (aimspress.com)

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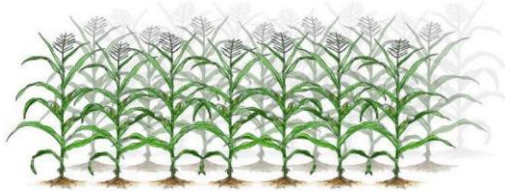
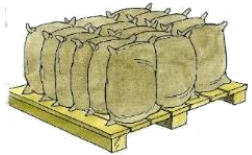
Organic farming systems for improved N balance



Continuous mono cropping system

Inter cropping system (crop diversification including push-pull, cover crop, crop rotation)



Low-quality inputs (synthetic, unaffordable)

High quality organic inputs (use of local renewable resources; manure, compost, Tithonia, plant extracts)

Inadequate management skills- limited knowledge

Farmer groups - Knowledge sharing, Training

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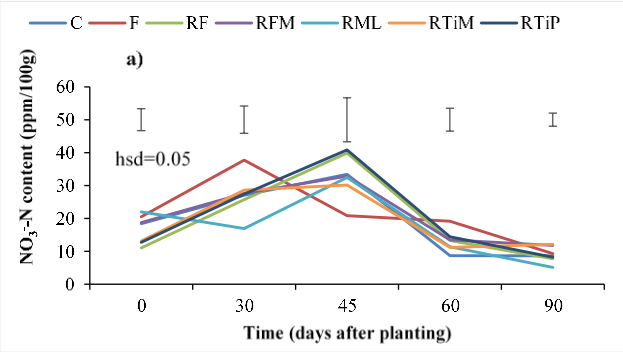
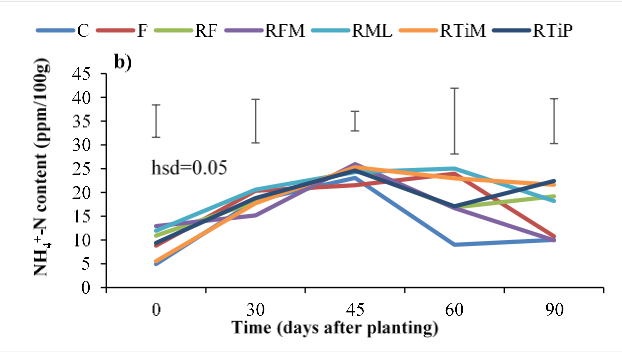
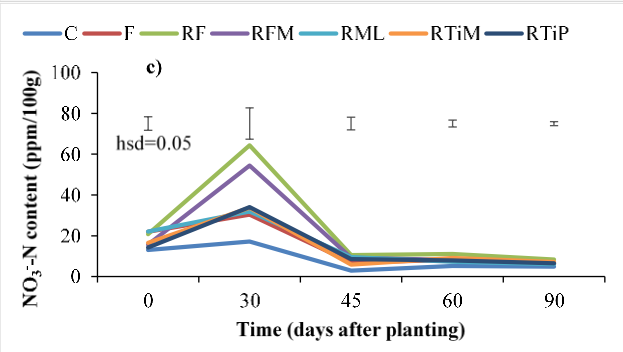
Mineral N response to various soil fertility resources

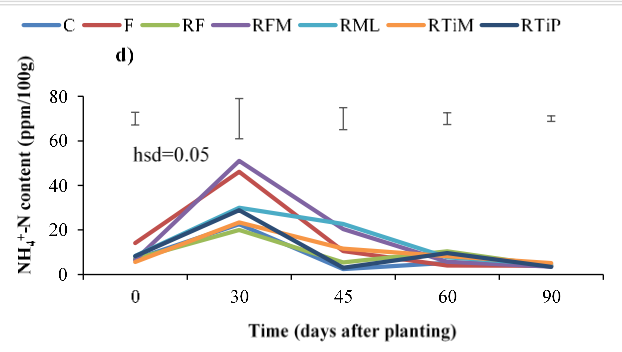
Short rain season

Long rain season









Zambia
Mali
Ghana

C= Control; F=mineral fertilizer; RF=crop residue + mineral fertiliser; RFM=crop residue + mineral fertilizer+ animal manure; RML=crop residue+ animal manure + legume intercrop; RTiM=crop residue + Tithonia diversifolia + animal manure, RTiP=crop residue + Tithonia diversifolia + phosphate rock

Kiboi et al. (2020) https://doi.org/10.4081/ija.2020.1381

Nitrogen balances in different farming systems and crop rotation

Kenya
Bolivia
India

	Chuka				Thika			
N input (kg ha^{-1})	Conv-high	Org-high	Conv-low	Org-low	Conv-high	Org-high	Conv-low	Org-low
N in Org inputs	357	1201	147	118	564	1644	125	158
N in mineral fertilizer	414	0	61	0	414	0	61	0
N in wet deposition	15	15	15	15	10	10	10	10
Total N fixation by legumes	81	43	43	77	40	213	18	20
Total Inputs (kg ha^{-1})	867^{d}	1359^{b}	266^{e}	211^{e}	1028^{c}	1867^{a}	214^{e}	188^{e}
N output (kg ha^{-1})								
Total N export	856^{a}	562^{bc}	525^{bc}	546^{bc}	1035^{a}	604^{b}	343^{c}	326^{c}
Soil surface N balance (kg ha^{-1})								
N balance	11^{c}	797^{b}	-259^{cd}	-335^{d}	-40^{cd}	1263^{a}	-134^{cd}	-117^{cd}

Conv-Low conventional low input system, Conv-High conventional high input system, Org-Low organic low input system, Org-High organic high input system
N in organic inputs includes N from FYM in conventional systems; Mucuna biomass, tithonia applied as mulch or plant tea, crop residues and mulch
N in mineral fertilizer includes N applied as diammonium phosphate and calcium ammonium nitrates
Calculated as N deposit from rainfall
N fixation from French bean in conv-High; Mucuna and French bean in Org-High and common beans in Conv- and Org-Low

Musyoka et al. (2019) https://doi.org/10.1007/s10705-019-10002-7

Lessons Learned for successful Organic farming systems

- Input preparation –Time & labour management (mechanization)
- Inputs availability, application timing & quality- good management
- Bolster knowledge and capacity building
- Soils N improvement need long-term research

Take-home message

- Organic farming **promotes** lower nutrient losses (N leaching, N_2O & NH_4 emission) hence positive N budgets – good management of organic inputs

- Intensive **research** on up-scaling methods and accurate estimation of N flows

- Integration of **policies** ; agricultural, environmental and socio-economic

FiBL, 2024 Cultivating change with agroecology and organic agriculture in the tropics (fibl.org)

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