Effect of organic and conventional farming systems on nitrogen use efficiencies of potato, maize, and vegetables in the sub-humid region of the central highlands of Kenya

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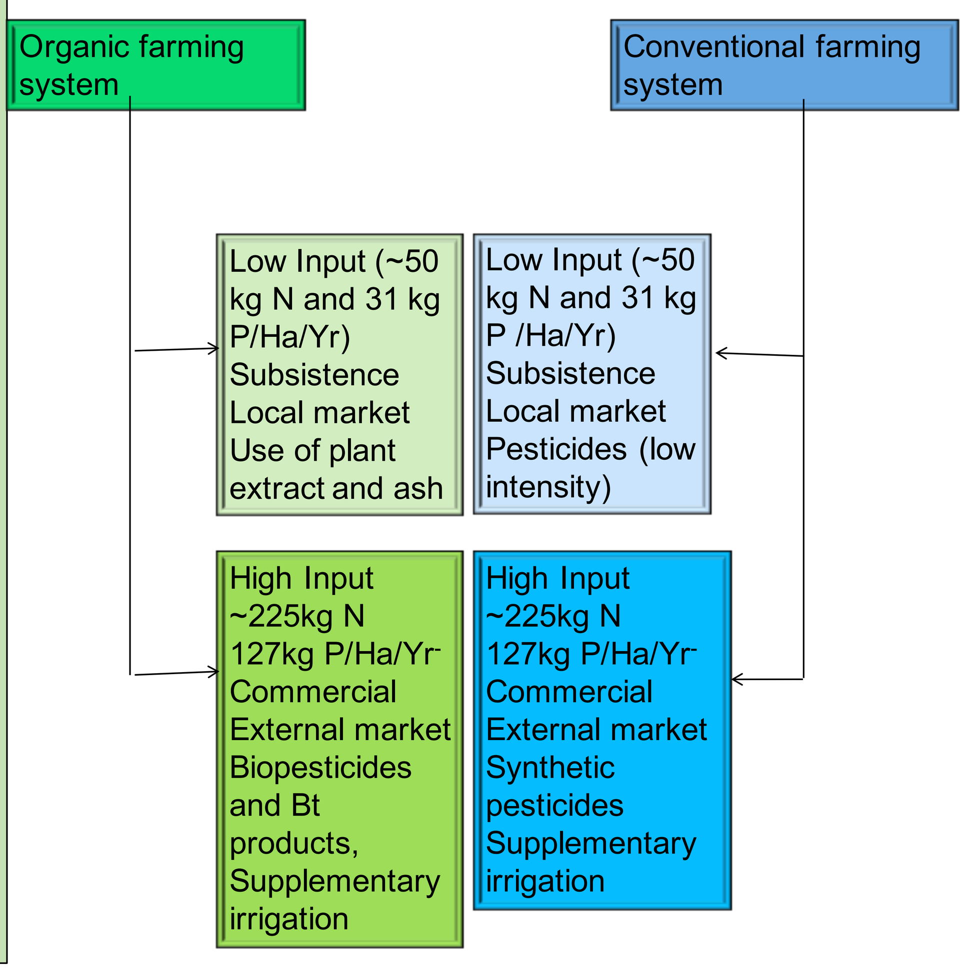
INTRODUCTION

Immediate need to increase per capita food production to match high population growth while maintaining environmental stability is an eminent challenge. Nitrogen (N) is one of the major limiting nutrients to food production in sub-Saharan Africa (SSA) (Bekunda et al., 2010). N management possess a major challenge due to its high mobility, and propensity for loss from soil-plant systems into the environment. Efficient N management techniques are required to improve N-delivery, and N-retention in soils, to increase N-use efficiency (NUE) and improve sustainability of most farming (Garnett et al., 2009). Adoption of appropriate soil management practices has been used to improve NUE (Ghosh et al., 2015; Kumar et al., 2015). Crop production systems like conservation tillage, organic, conventional, and integrated farming systems that make use of improved crop varieties with efficient use of N have been perceived to have major effects on NUE (Ladha et al., 2005; Hirel et al., 2011). Farming systems in the tropics rely on small farm size for both subsistence and commercial purposes, and it is envisaged that organic or conventional farming systems in the long term may affect nitrogen transformation in soils differently and thus crop N uptake and utilisation.

Data collection

- Above-ground crops were harvested from the 6 x 6 m net plot
- Potatoes were separated into tubers and haulms, maize into grain, cobs, husks and stovers, and cabbage into cabbage head and biomass.
- Plant samples were oven-dried at 60˚C to a constant weight to determine the dry matter yield (DMY) except grain samples which was determined at 13% moisture content with a grain meter and analysed for total N.
- Yield or biomass DMY was then expressed in grammes per plant.
- NUE components for different crops calculated at harvest include: agronomic efficiency of N (AE_N), N uptake efficiency (NUpE), N utilisation efficiency (NUtE) and N harvest Index (NHI).

Farming systems



CONCLUSION

- With the exception of potato, conventional and organic farming systems have similar effect on maize and vegetable crops NUE.
- There was the likelihood of residual N accumulating after potato cultivation in the high input organic systems and this might pose a threat to underground and surface water bodies if lost into the environment.
- Nutrient mining was also suspected in conventional systems when cabbage was grown after maize resulting to soil fertility depletion.

RECOMMENDATIONS

It is paramount to monitor the effect of the systems on N leaching and nutrient mining, and to evaluate the protein content of foodstuffs from both systems (as NHI in maize and vegetables was similar).

IMPACT

- The research improves the productivity of organic and conventional systems, and thus contributes positively to food security.
- Promotes use of locally available resources to increase soil productivity and thus an integration of use of natural resource to food security.
- Generated information will support organic farming as a potential option for rebuilding soil fertility for resource poor farmers.
- Understanding N dynamics under organic and conventional systems will help us to understand the resilience of the systems in coping with climate change.
- With measures to develop organic agriculture policy in Kenya already in place, these results will provide factual data for informed policy decisions, and thus promote sustainable farming systems based on well-informed decisions taken by farmers, which will result in improved productivity.

OBJECTIVES

To determine the effect of organic and conventional farming systems managed at different input levels on N-uptake, and nitrogen use efficiency at Chuka and Thika sites in the central highlands of Kenya

METHODS: Cropping cycle

Farming systems	Year 2007, 2010, 2013		Year 2008, 2011, 2014		Year 2009, 2012, 2015	
	LS*	SS**	LS	SS	LS	SS
Conv-High[1]	Maize	Cabbage	Baby corn	French beans	Baby corn	Potatoes
Org-High[2]	Maize/*Mucuna*†	Cabbage	Baby corn/*Mucuna*	French beans	Baby corn/*Mucuna*	Potatoes
Conv-Low[3]	Maize	Collard/Swiss chard	Maize/Beans	Grain legumes	Maize-beans	Potatoes
Org-Low[4]	Maize	Collard/Swiss chard	Maize/Beans	Grain legumes	Maize-beans	Potatoes

Mucuna planted as rely crop four weeks after maize or baby corn establishment. The biomass of *Mucuna* is always applied in the short rains season crops

RESULTS

- N partitioned into potato tubers was higher in Conv-High
- ($P < 0.001$) than the N partitioned into tubers in Org-High
- Higher N was partitioned into tubers in low input systems
- Conv-High and Org-High had similar effect on N partitioned into maize grain and cabbage heads
- Low input systems performed poorly during maize and vegetable season due to drought.

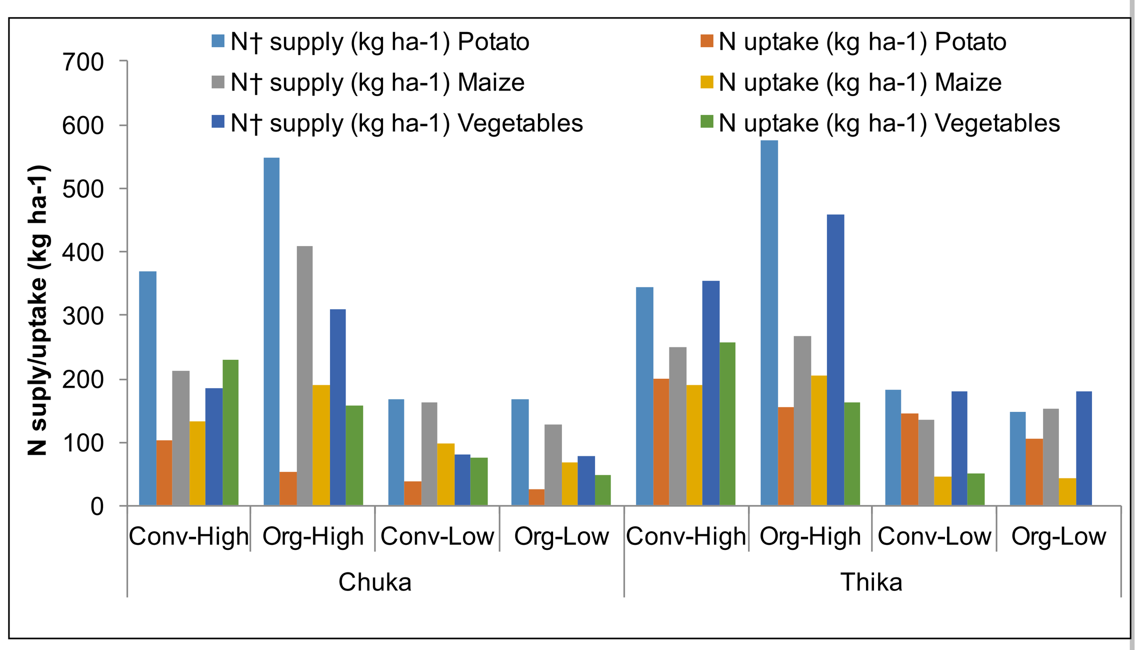


Fig 1. N supply and uptake in different crops managed under different farming systemss

Effect of farming systems on Nitrogen use efficiency of potato, maize, cabbage, collard and Swiss chard

Site	Farming systems	……………...Potato………				………………….Maize……………. ….				………Cabbage*/Collard**……… …			
		NUpE	NUtE	AE_N	NHI	NUpE	NUtE	AE_N	NHI	NUpE	NUtE	AE_N	NHI
		---------------g g^{-1}N---- -------			%	---------------g g^{-1}N---------- ------			%	-------g g^{-1}N--------			%
Chuka	Conv-High	0.28 a	24 a	12.0 a	71 ab	0.63 ab	25.8 ab	46.0 a	50 a	1.23 a	15.3 ab	30.3 a	66 ab
	Org-High	0.07 c	18 b	1.3 c	64 b	0.46 b	24.4 ab	29.7 b	48 a	0.83 a	18.0 a	19.8 a	78 a
	Conv-Low	0.32 β	29 α	9 β	79 αβ	0.60 α	15.0 α	37.1 α	33 α	0.57 α	40.6 αβ	23.5 α	67αβ
	Org-Low	0.16 β	25 α	4 β	75 β	0.53 α	18.5 α	35.4 α	37 α	0.36 α	50.2 α	15.7 αβ	45 β
Thika	Conv-High	0.53 a	23 a	12.0 a	83 a	0.77 a	26.0 ab	55.1 a	54 a	0.45 b	9.2 c	11.2 b	43 c
	Org-High	0.26 b	21 ab	5 b	75 ab	0.77 a	27.5 a	54.9 a	52 a	0.36 b	12.3 bc	8.6 b	57 bc
	Conv-Low	0.86α	30 α	25 α	87 α	0.34 β	1.4 β	18.7 β	6 β	0.48 α	15.4 β	7.2 β	99 α
	Org-Low	0.76 α	27 α	20 α	81 αβ	0.28 β	1.3 β	15.5 β	3 β	0.43 α	13.0 β	4.8 β	99 α

a, b, c letters were used to compare means of high input systems while α, β, ɤ were used to compare means of low input system

- Conv-High had higher NUpE, NUtE, AEN and NHI of potato compared to Org-High but Conv-Low and Org-Low had similar effects on NUpE, NUtE, AEN and NHI of potato.
- Conv-High and Org-High had similar effects on NUpE, NUtE, AE_N and NHI of maize and cabbage
- Conv-Low and Org-Low had similar effects on NUpE, NUtE, AE_N and NHI of maize and kale/spinach intercrop.

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