Effect of organic and conventional farming systems on nitrogen uptake and leaching under potato, maize, and vegetable crops in the sub humid region of the Central Highlands of Kenya

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INTRODUCTION

The immediate need to increase per capita food production to match high population growth while maintaining environmental stability is a big challenge. Nitrogen (N) is one of the major limiting nutrients to food production in sub-Saharan Africa (SSA) (Bekunda *et al.*, 2010). N management poses a major challenge because of its high mobility and the 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 farming (Garnett *et al.*, 2009). To improve NUE, adoption of appropriate soil management practices has been used (Ghosh *et al.*, 2015; Kumar *et al.*, 2015).

Crop production systems such as 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 might affect nitrogen transformation in soils; and consequently, crop N uptake and use.

FARMING SYSTEMS DESCRIPTION

Farming systems	Planting density	Fertiliser		Pest and disease control		Irrigation	Weed control	Market	N (kg ha yr^{-1})	P (kg ha yr^{-1})
		Type	Rate	Type	Intensity					
Conv-High	One plant per hole	INM	High	IPM	High**	Supplementary Irrigation*	Hand	High value	225	127
Org-High	One plant per hole	organic	High	Biopesticides	High**	Supplementary Irrigation*	Hand	High value	225	127
Conv-Low	Two plants per hole***	INM	Low	IPM	Low#	Rain-fed	Hand	Subsistence and local	50	31
Org-Low	Two plants per hole***	organic	Low	Ash and Biopesticides	Low#	Rain-fed	Hand	Subsistence and local	50	31

INM = Integrated nutrient management; IPM = Integrated pest management; *Irrigation given only during periods of drought; **Based on scouting for pests and diseases;***two plants per hole for maize and beans, but one plant per hole for vegetables, #control based on when the pests and diseases are observed.

DATA COLLECTION

- N supply was assessed as N applied from specific inputs plus mineralised N during the season.
- Mineralised N was measured using the buried bag approach.
- N uptake was assessed at harvest for all the crops (both biomass and economic yields).

IMPACT

- The research improves the productivity of organic and conventional systems, thus contributing to food security.
- The research promotes use of locally available resources to increase soil productivity, thus integrating the use of natural resources for food security.
- The 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, thus promoting sustainable farming systems based on well-informed decisions taken by farmers, which will result in improved productivity.

CONCLUSIONS

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

RECOMMENDATIONS

It is paramount to monitor the sustainability of the systems in the long-term given the residual and mining effects observed.

OBJECTIVE

- 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	Maize	Cabbage	Baby corn	French beans	Baby corn	Potatoes
Org-High	Maize/*Mucuna***	Cabbage	Baby corn/*Mucuna*	French beans	Baby corn/*Mucuna*	Potatoes
Conv-Low	Maize	Collard/Swiss chard	Maize/Beans	Grain legumes	Maize/beans	Potatoes
Org-Low	Maize	Collard/Swiss chard	Maize/Beans	Grain legumes	Maize/beans	Potatoes

*LS=Long rains season. **SS=Short rains season. ***Mucuna planted as relay crop four weeks after maize or baby corn establishment. The biomass of *Mucuna* is always applied in the short rains season crops

RESULTS

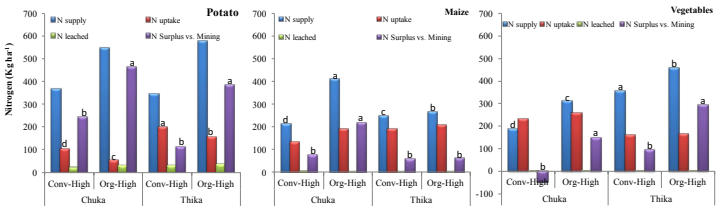

Figure 1: N supply uptake and leaching under different crops managed under Org-High and Conv-High farming systems

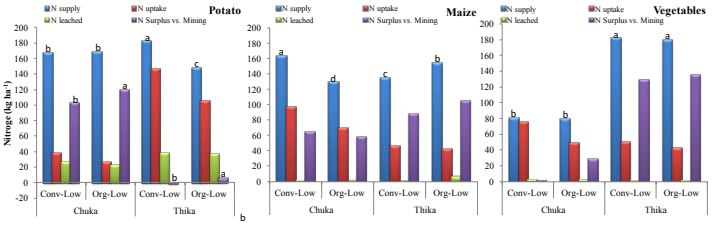

Figure 2: N supply uptake and leaching under different crops managed under Org-Low and Conv-Low farming systems

- N partitioned into potato tubers was higher in conventional systems than in organic systems.
- Conv-High and Org-High had similar effect on N uptake and leaching under maize and cabbage.
- Low input systems performed poorly during maize and vegetable season due to drought.
- There was low N leached during maize and vegetable seasons.
- Higher residual effects were observed under potato and also in Org-High systems.

REFERENCES

Bekunda, M., Sanginga, N., Woomer, P.L., 2010. Restoring soil fertility in sub-Saharan Africa. *Advances in Agronomy* 108, 183–236.

Garnett, T., Conn, V., Kaiser, B.N., 2009. Root based approaches to improving nitrogen use efficiency in plants. *Plant, Cell & Environment* 32, 1272–1283.

Ghosh, B.N., Singh, R.J., Mishra, P.K., 2015. Soil and input management options for increasing nutrient use efficiency. In: Rakshit, A., Singh, H.B., Sen, A. (Eds.), *Nutrient Use Efficiency: From Basics to Advances*. Springer India, pp. 17–27.

Hirel, B., Tétu, T., Lea, P.J., Dubois, F., 2011. Improving nitrogen use efficiency in crops for sustainable agriculture. *Sustainability* 3, 1452–1485.

Kumar, R., Parmar, B., Walia, S., Saha, S., 2015. Nitrification inhibitors: Classes and its use in nitrification management. In: Rakshit, A., Singh, H.B., Sen, A. (Eds.), *Nutrient Use Efficiency: From Basics to Advances*. Springer India, pp. 103–122.

Ladha, J.K., Pathak, H., Krupnik, T.J., Six, J., van Kessel, C., 2005. Efficiency of fertilizer nitrogen in cereal production: Retrospects and prospects. Advances in Agronomy 87, 85–156.

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