Conservation Agriculture Practices in Smallholder Farming of Western Kenya: Nutrient Cycling and Greenhouse Gas Fluxes

Urszula Norton[1&2], Judith Odhiambo[1], Jay Norton[3]

[1]Department of Plant Sciences, University of Wyoming, USA; [2]Program in Ecology, University of Wyoming, USA; [3]Department of Ecosystem Science and Management, University of Wyoming, USA

Rationale

- Long-term history of continuous cropping and deep inversion plowing in conjunction with current weather uncertainties are major threats to sustainability of rain-fed small-scale farming systems in Sub-Saharan Africa (SSA).
- Conservation Agriculture (CA) is gaining a widespread acceptance not as an alternative, but rather necessity to increase food production by food-insecure smallholder farmers.
- Limited understanding of short-term agroecosystem response during transition to CA can impede the process of farmers' adoption.

Objectives

Explore short-term impacts of CA practices on:

- Early indices of the soil change
- Crop competition with weeds
- Operational costs

Methods

Three sampling campaigns (May, September, January) for three years

LCBD with 4 replications

Soil (0-10 cm) analyzed for potentially mineralizable N (PMN)

Gas samples analyzed for CO_2

Weed population: every May

Location

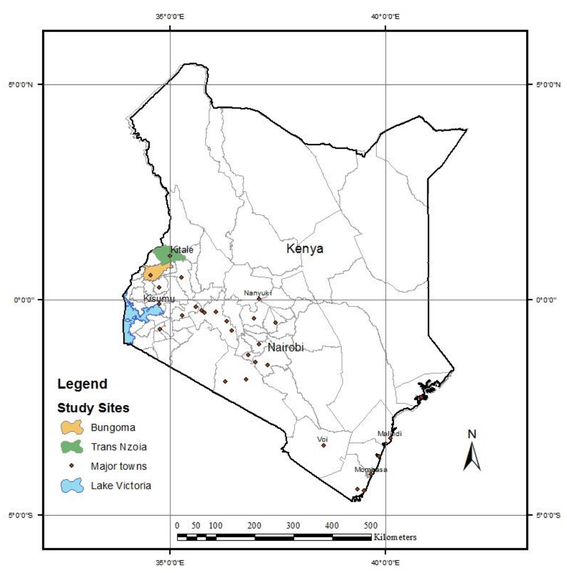

Figure 1: Study sites

Bungoma (two growing seasons : Long and Short)
Elevation: 1433 meters asl;
MAT: 27^{0}C &MAP:1200mm

Trans-Nzoia (one long growing season)
Elevation: 1890 meters asl;
MAT:20^{0}C & MAP: 1500mm

Treatments

TILLAGE:

CT-inversion-type tillage (to 25 cm) for land preparation and deep hoeing for weed control

MT- shallow tillage (to 10 cm) and a combination of shallow hoeing and chemical weed control

NT- no till and chemical weed control

CROPPING (Table 1):

Location	Cropping system	Long Growing Season	
Trans-Nzoia	CT	Maize1/Beans1	Maize1/Beans2
	RELAY	Maize1/Beans	Maize1/Mucuna
	STRIP	Maize1-Beans1-Mucuna	Maize1-Beans2-Mucuna
		Long Rains	**Short Rains**
Bungoma	CT	Maize1/Beans1	Maize2/Beans2
	RELAY	Maize1/Beans	Maize2/Mucuna
	STRIP	Maize1-Beans1-Mucuna	Beans2-Mucuna-Maize2

Soil Mineralizable N and C

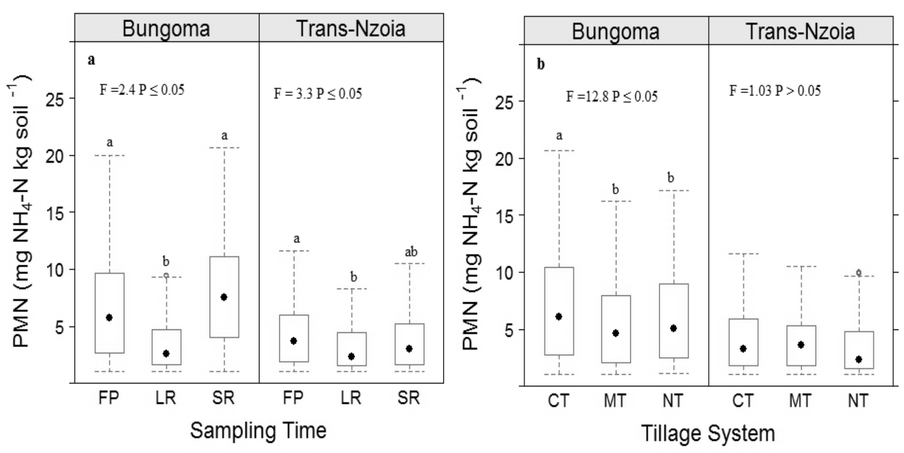

Figure 2: Soil Potentially Mineralizable N (PMN)

Greater organic N mineralization during short rains (SR) and fallow (FP) in Bungoma

Minimum tillage (MT) and no-till (NT) reduce soil N mineralization in Bungoma only

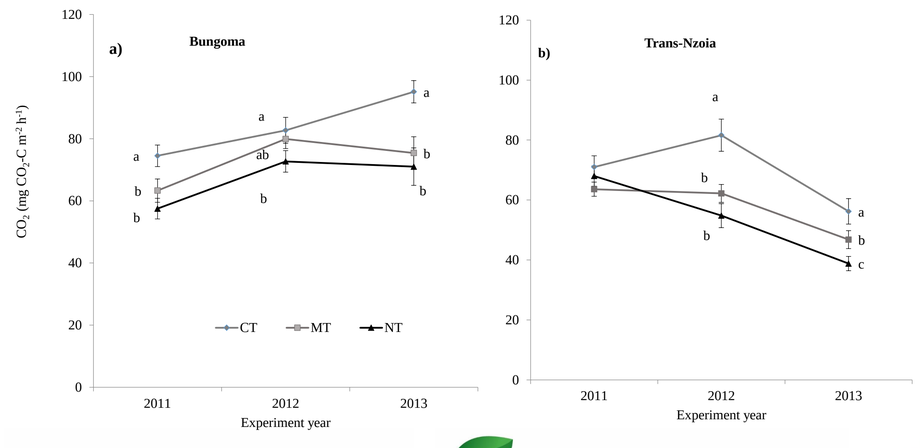

Figure 3: Soil Mineralizable C (CO_2 respiration)

High overall C mineralization in Bungoma

Immediate declines after tillage reduction (both MT and NT) especially in Trans-Nzoia

Yields, Weed Dynamics and Costs

Table 2: Crop yields for Bungoma (2 seasons) and Trans-Nzoia (one long growing season)

Cumulative yields (tons ha^{-1})	Bungoma	Trans-Nzoia
Maize	1.33b	2.00a
Beans	0.2b	0.7a

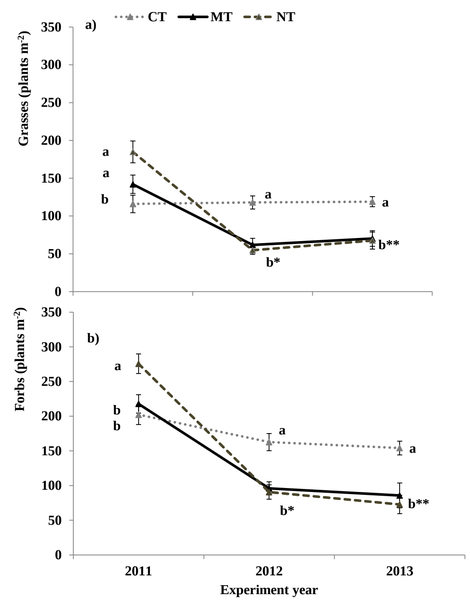

Figure 4: Populations of weedy grasses and forbs (Trans-Nzoia only)

No change in weedy species populations in CT over time

Significant declines in a number of grasses and forbs in MT and NT following appropriate technology transfer and herbicide application training

Table 3: Operational costs associated with land management

			COSTS								
			CT			MT			NT		
Management	Mode/Active Ingredient	Freq./Rate	Materials	Labor	Total	Materials	Labor	Total	Materials	Labor	Total
			US Dollars ha^{-1}								
Weed Control during Land Preparation:											
Tillage	Animal Drawn Moldboard Plow	2x		144.00							
Harrowing	Hand Hoe	1x		72.00	**144.00**						
Planting	Hand Hoe	1x		50.00	**72.00**		50.00	**50.00**			
	Jab Planter	1x			**50.00**					50.00	**50.00**
TOTAL			0.00	266.00	**266.00**	0.00	50.00	**50.00**	0.00	50.00	**50.00**
Weed Control after Planting:											
Tillage	Hand Hoe	2x (CT)		216.00	**216.00**		108.00	**108.00**			
Herbicides:		1x (MT)									
Dual Gold ®	S-Metachlor 960 g L^{-1}	576 g ha^{-1}				54.20	36.50	**90.70**	54.20	36.50	**90.70**
Touchdown ®	Glyphosate 500 g L^{-1}	750 g ha^{-1}				48.40	36.50	**84.90**	48.40	36.50	**84.90**
Basagran ®	Bentazone 400 g L^{-1}	600 g ha^{-1}							33.80	73.00	**106.80**
TOTAL			0.00	216.00	**216.00**	102.60	181.00	**283.60**	136.40	146.00	**282.40**
GRAND TOTAL			0.00	482.00	***482.00***	102.60	231.00	***333.60***	136.40	196.00	***332.40***

Table 3 discussion: Costs of weed management reduced by \$148.40 ha^{-1} in minimum till and \$149.60 ha^{-1} in no-till compared with conventional tillage

Most of the cost reduction from less manual labor and tillage operations

Conclusions

- *The earliest indices of change relate to successful technology transfer associated with chemical weed management as a part of the reduced tillage*
- *Reduced tillage demonstrates immediate slow down of the process of soil C and N mineralization*
- *Foregoing second planting in Bungoma can improve agroecosystem resilience but may be a challenge to deploy*
- *CA practices based on alternative cropping are slower to realize compared with tillage reduction*

USAID FROM THE AMERICAN PEOPLE

SANREM INNOVATION LAB
Feed the Future Innovation Lab for Collaborative Research on Sustainable Agriculture and Natural Resource Management

Schlumberger Foundation Faculty for the Future

University of Wyoming