Early Indicators of Change during Transition to Conservation Agriculture Practices by Smallholder Framers in Western Kenya

Urszula Norton*
Jay Norton
Judith A. Odhiambo
Emmanuel Omondi

University of Wyoming

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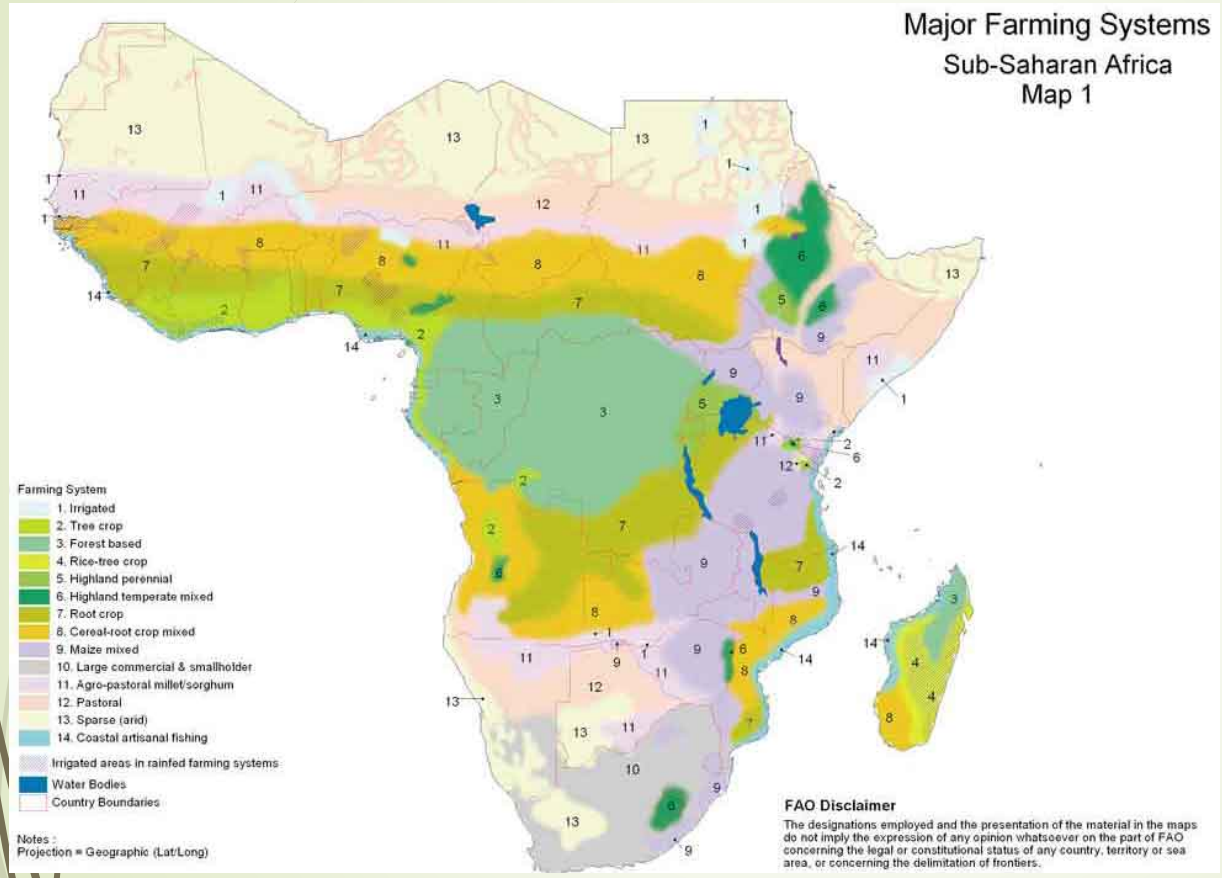
Introduction



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Many smallholder farmers in Sub-Saharan Africa grow maize (*Zea mays L.*) intercropped with common beans (*Phaseolus vulgaris L.*)

Introduction

- Heavily weathered and nutrient-poor soils
- Deep inversion-type tillage and little to no fertilizer inputs
- Low yields
- In many regions, crops are grown twice per year during long rainy season (LR) and short rainy season (SR)
- Growing crops twice per years necessitates more frequent land preparation and soil disturbance

Possible Solutions

Conservation Agriculture Practices (CAPs) can promote sustainable land use and food production while addressing social, environmental and economic constraints of small-holder farmers

Co-designed by farmers and researchers

Crop diversification, use of cover crops, soil residue retention, reduced soil disturbance

Limited Success of Adoption

- Will crop yields be affected during transition?
- **Will weed competition change?**
- **How soon the benefits to soil can become apparent?**
- **Unknown costs of alternative management operations**

Objectives

Identify and assess soil and plant parameters during transition to selected CAPs identified by small-holder farmers in western Kenya

Bungoma
Elevation: 1433 meters
MAT: 27˚C
MAP: 1200mm
Soil TC/TN: 2.0/0.2g kg^{-1}

Trans-Nzoia
Elevation: 1890 meters
MAT: 20˚C
MAP: 1500mm
Soil TC/TN: 3.0/0.3g kg^{-1}

Soils
kaolinite-derived clay loams (Ferrasols)
pH of 5.2

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:

TYPICAL-continuous maize/bean intercropping

RELAY-maize/bean intercropping followed with mucuna (M*ucuna pruriens)* after bean harvest

Materials and Methods

Three campaigns per year (Long Rains, Short Rains, Fallow Period) for three years

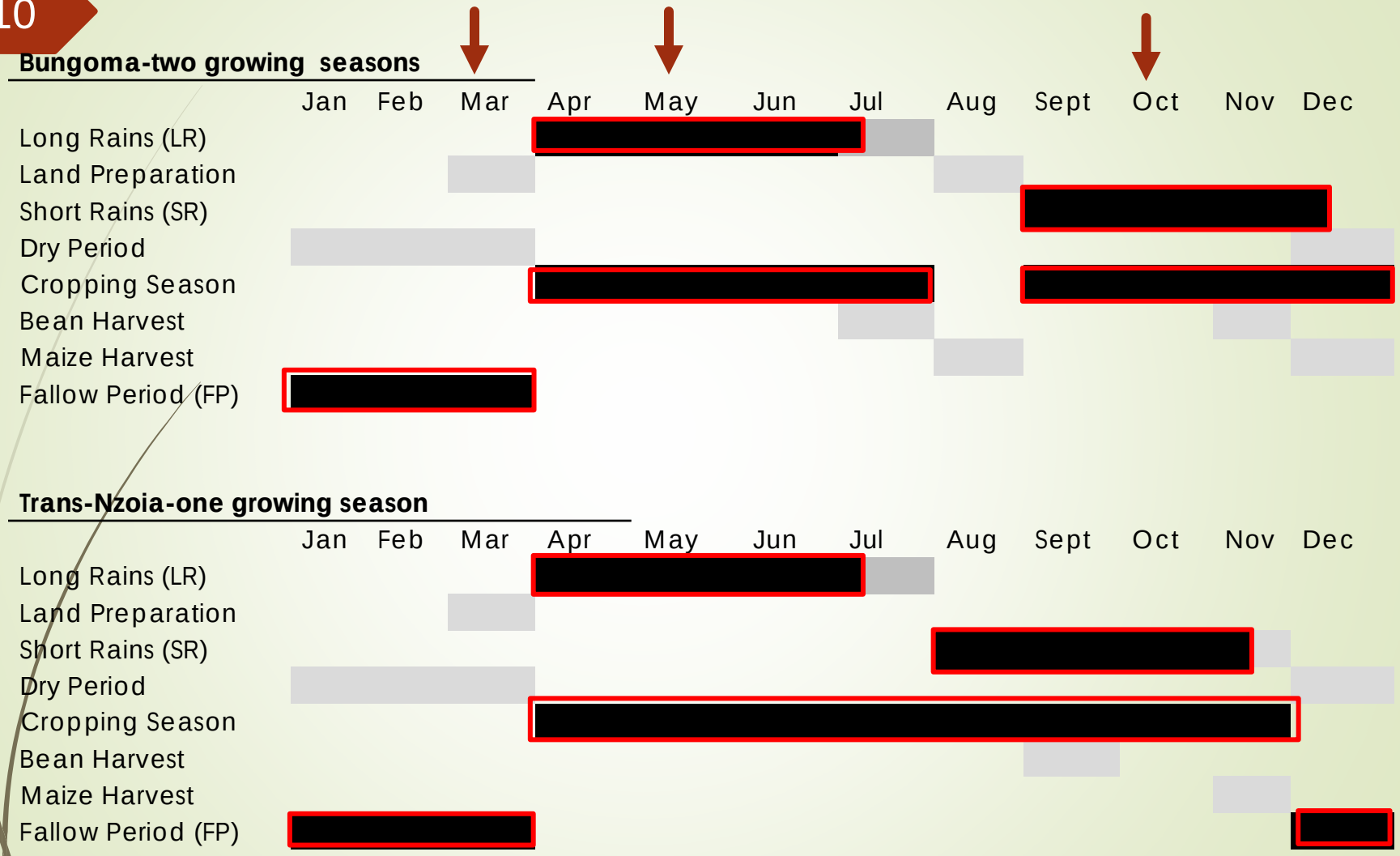
Four fields, four10 m x 10 m plots per field: two plots near maize plants and two near bean plants

Soil (0-10 cm) pre-incubated and analyzed for NH_4 and potentially mineralizable N (PMN)

Gas samples analyzed for N_2O and CO_2

Weed population: Once a year during Long Rains

Seasons

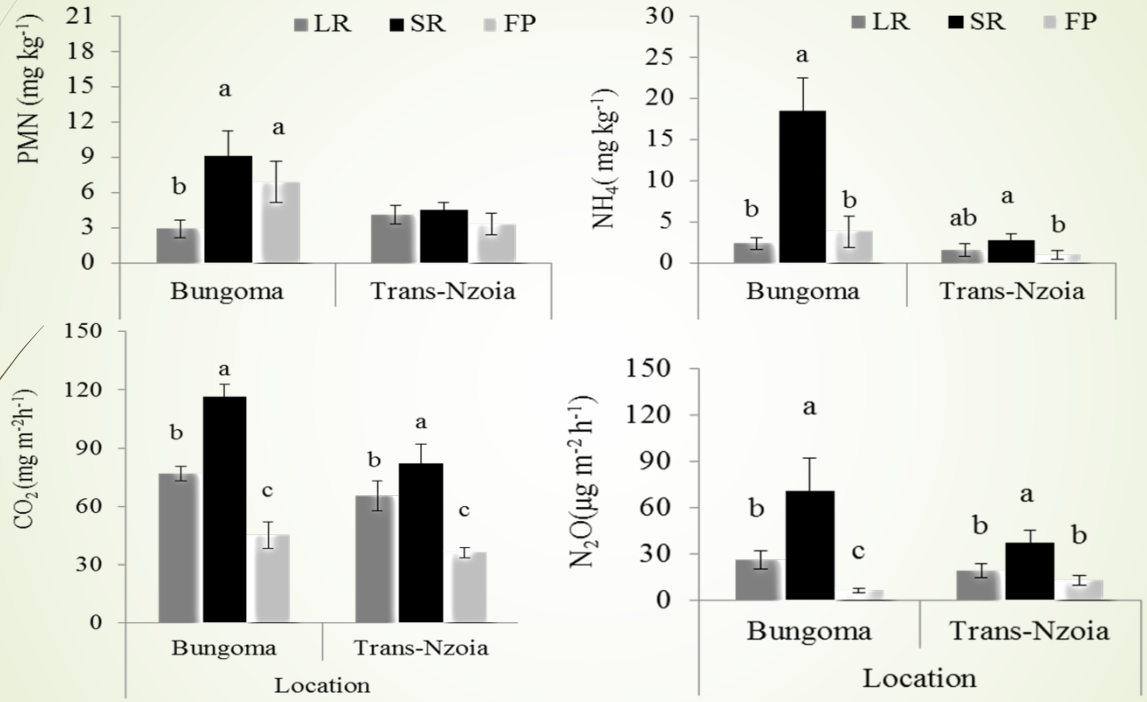

Bungoma-two growing seasons
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec
Long Rains (LR)
Land Preparation
Short Rains (SR)
Dry Period
Cropping Season
Bean Harvest
Maize Harvest
Fallow Period (FP)
Trans-Nzoia-one growing season
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec
Long Rains (LR)
Land Preparation
Short Rains (SR)
Dry Period
Cropping Season
Bean Harvest
Maize Harvest
Fallow Period (FP)

CT-TYPICAL Crop Yields

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

Lower cumulative yields despite two growing seasons in Bungoma

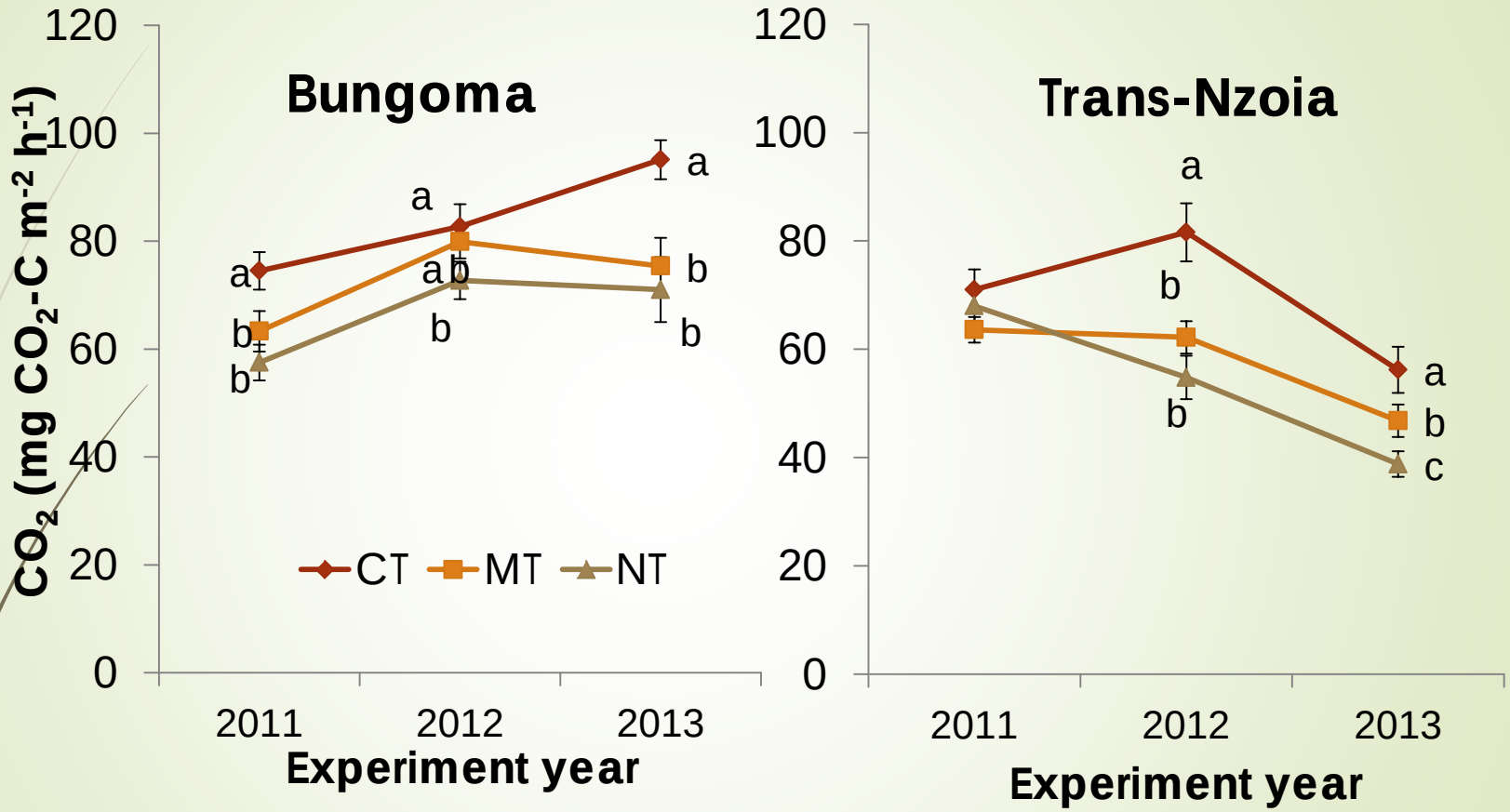
CT-TYPICAL
Soil labile N and GHG Fluxes



Greater C and N mineralization in Bungoma

Second cropping during SR triggers more potential C and N losses to GHG and leaching

Reduced Tillage and CO_2 Fluxes



- More carbon retention under reduced tillage
- Early response in Bungoma

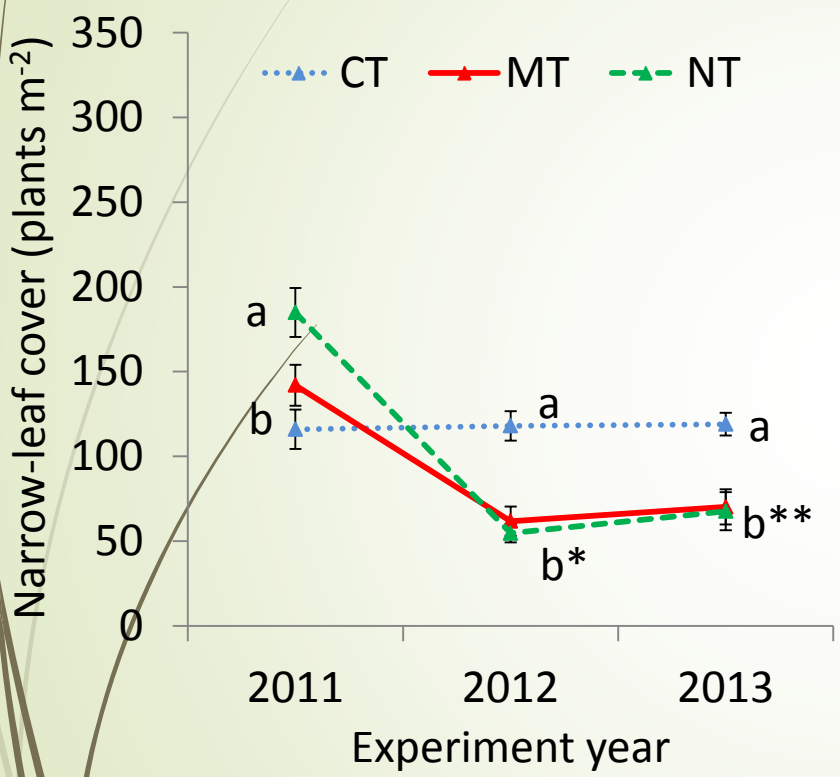
Reduced Tillage and Altern. Cropping GHG Fluxes

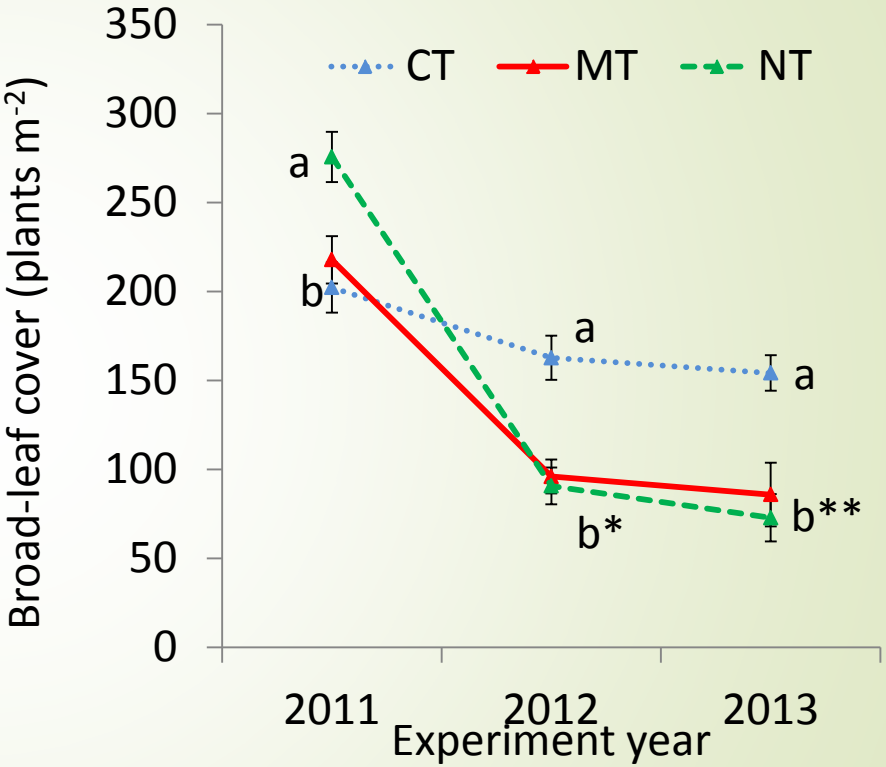
		Bungoma		Trans-Nzoia	
		Cropping System		*Cropping System*	
	Tillage	*TYPICAL*	*RELAY*	*TYPICAL*	*RELAY*
CO_2 (mg m^{-2} hr^{-1})	CT	79.5 (10.3)	75.4 (9.2)	61.3(8.8)	60.7 (6.4)
	MT	72.8 (14.0)	74.5 (9.2)	55.7 (6.6)	50.4 (6.9)
	NT	64.5 (3.9)	60.0 (3.7)	52.0 (9.0)	48.2 (5.1)
N_2O (µg m^{-2} hr^{-1})	CT	35.2 (15.6)	45.1 (16.9)	24.9 (3.4)	32.4(4.4)
	MT	38.9 (16.3)	34.9 (11.9)	22.7 (3.7)	19.4 (3.8)
	NT	36.4(11.4)	41.8 (10.7)	24.4 (3.4)	17.9 (2.5)

NT has the greatest short term impact by lowering CO_2 fluxes
RELAY cropping reduces N_2O regardless of the tillage especially in Trans-Nzoia

Reduced Tillage and Weed Dynamics

Trans-Nzoia





Immediate declines in grasses and forbs in response to reducing tillage

Reduced Tillage and Weed Species

Trans-Nzoia

			Tillage system		
Scientific Name	Common name	Life-form	CT	MT	NT
			Number of individuals m^{-2}		
Ageratum conyzoides L.	**Goat Weed**	Broad	69.0	66.0	64.0
Digitaria abyssinica L.	**Couch Grass**	Narrow	45.0a	30.0	44.0
Commelina benghalensis L.	**Benghal Day Flower**	Broad	41.0.0a	11.0	7.0
Cyprus rotundus L.	**Nut Grass**	Narrow	40.0a	12.0b	9.0
Bidens pilosa L.	**Black Jack**	Broad	34.0a	22.0ab	20.0
			Cropping system		
			TYPICAL	RELAY	
Ageratum conyzoides L.	**Goat Weed**	Broad	84.0	66.0	
Digitaria abyssinica L.	**Couch Grass**	Narrow	54.0a	34.0	
Commelina benghalensis L.	**Benghal Day Flower**	Broad	21.0a	18.0	
Cyprus rotundus L.	**Nut Grass**	Narrow	22.0a	16.0	
Bidens pilosa L.	**Black Jack**	Broad	18.0	24.0	

Reducing tillage and RELAY cropping effectively reduces weed population of four most dominant groups except for Goat Weed

Reduced Tillage and Costs of Weed Control

Trans-Nzoia

	CT			MT			NT		
	Materials	Labor	Total	Materials	Labor	Total	Materials	Labor	Total
	US dollars ha^{-1}								
Inputs	740	-	**740**	740	-	**740**	740	-	**740**
Land Prep	-	**308**	**308**	-	50	**92**	-	80	**122**
Weed Control	-	216	**216**	138	290	**428**	138	218	**356**
	740	524	**1264**	878	382	**1260**	878	340	**1218**

- Costs in CT driven by highest demand for labor during land prep

Conclusions

- CAPs demonstrate early promise of improved soil SOM storage by reducing C and N mineralization during the first three years
- Reduced tillage-based CAPs show immediate improvement in weed control and costs
- RELAY cropping that introduces mucuna after bean harvest improves soil N cycling by lowering N mineralization and shows early signs of improved weed control
- Forgoing crop production during SR or utilizing techniques to build up SOM during this time through reduced tillage and RELAY cover crop use can help improve farmers' livelihoods in Bungoma

Questions?