International Potato Center (CIP)

University of Nairobi

EFFECT OF POTATO (*Solanum tuberosum* L.) CROPPING SYSTEMS ON SOIL AND NUTRIENT LOSSES THROUGH RUNOFF IN A HUMIC NITISOL, KENYA

Session SSS2.12.

EUROPEAN GEOSCIENCES UNION

2016 General Assembly, Austria

Shadrack Nyawade (University of Nairobi-Kenya), Gachene C.K.K (University of Nairobi-Kenya), N.K.Karanja (University of Nairobi-Kenya), Elmar Schulte-Geldermann (CIP-Kenya)

INTRODUCTION

- Soil erosion causes soil loss at a rate of 75 billion tons/yr from world agricultural systems, and 2.5 billion tons/yr in East Africa.

- Potato production contributes about 70% of these losses in Kenyan Highlands as the crop establishes a protective soil cover only at 45-60 days after planting.

Cont’

- Changes in **soil surface roughness** (SSR) due to potato hilling has been shown to contribute to some of these losses(Longshan *et al*., 2014).

- Limited studies have taken into consideration that **crop cover** can **interact** with **SSR** to influence runoff and soil loss.

- There has also been a growing attempt to **partition** the eroded SOM into **stable and labile** fractions with **different** results being found (Jacinthe *et al*., 2004; Wang *et al*., 2014).

Objectives

- The study aimed at identifying a potato (*Solanum tuberosum* L.) cropping system that will minimize soil erosion and ensure sustainable soil productivity. **Specifically** , the study sought to:

- assess the effect of soil surface roughness and crop cover on soil loss under different potato cropping systems.

- evaluate the effect of potato cropping systems on nutrient enrichment ratio due to erosion in a humic nitisol.

- determine soil organic matter fraction most susceptible to soil erosion under different potato cropping systems.

METHODOLOGY

Experimental Site: The study was conducted at the University of Nairobi Research Farm during short and long rain seasons of 2014/15 respectively.

Soils are classified as humic Nitisols (Alfisols).

- 20 runoff plots were laid out in a RCBD on a natural slope averaging 12%.

5 **treatments** were each replicated 4 times:

- T1: Bare Soil
- T2: Potato + Garden Pea (*Pisum sativa*).
- T3: Potato + Climbing Bean (*Phaseolus vulgaris*)
- T4: Potato + *Dolichos lablab* (*Lablab purpureus*)
- T5: Sole Potato (*Solanum tuberosum L.*)

The experimental layout

DATA COLLECTION AND STATISTICAL ANALYSES

Soil surface roughness was determined using relief meter (Kuipers, 1957)

Cover was estimated using point frame (Coxson, 1986)

Soil organic matter was physically fractionated into labile and stable fractions(Cambardella & Elliott, 1992)

Cont'

- Soil pH was determined on a 1:2.5 ratio of soil to water, total N-Kjeldahl digestion, available P-Bray, K-flame photometric, and SOC by wet oxidation.

- Soil loss was analyzed according to procedures by Wendelaar and Purkis, (1979).

- Enrichment Ration was calculated as the ratio of nutrient element in the eroded sediment to that in the top source soil (Lal and Polyakov, 2004).

Statistical Analyses

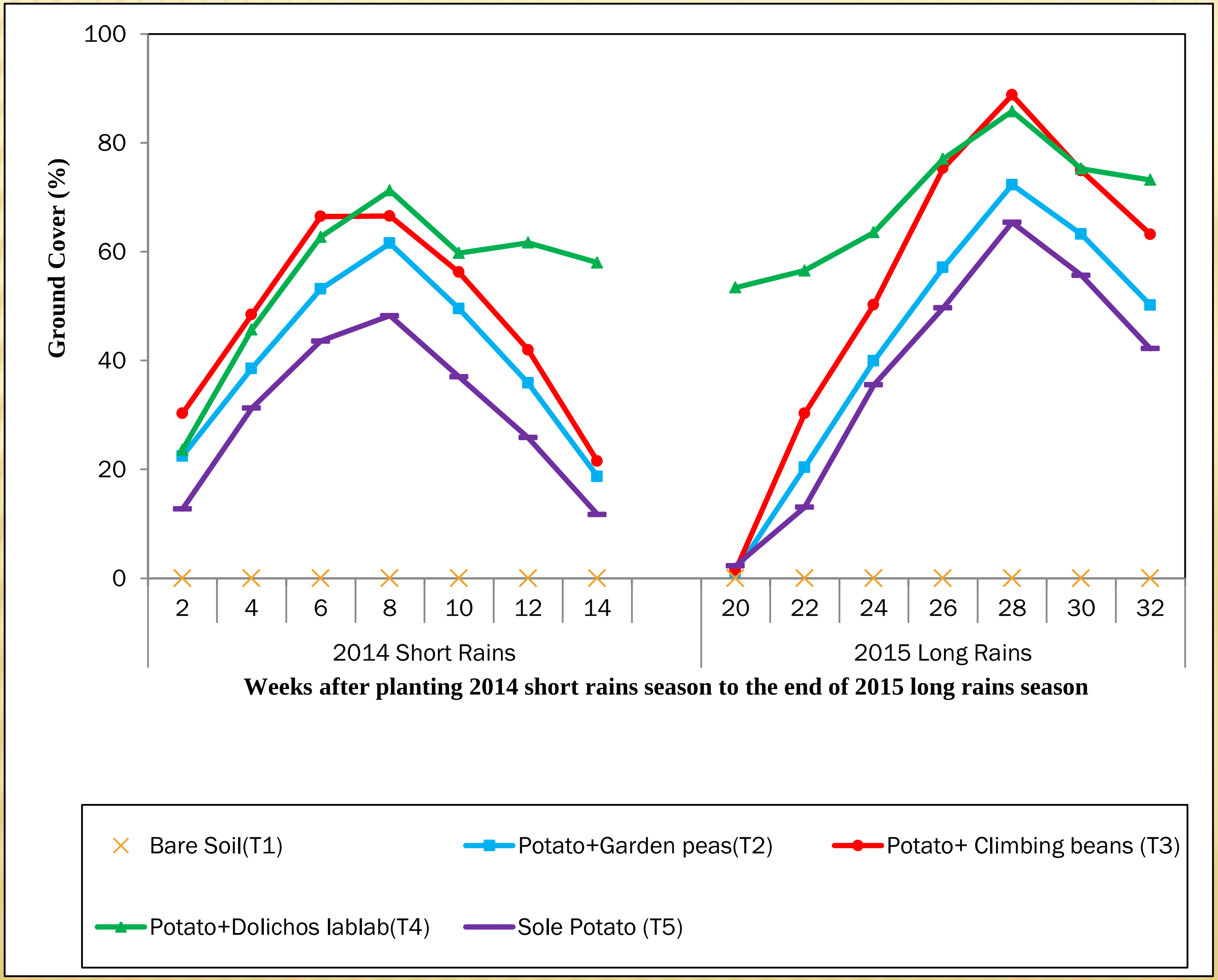
- Data was subjected to ANOVA using Genstat and statistical significance determined at P ≤0.05.

- Means were separated by Fischer's protected LSD test.

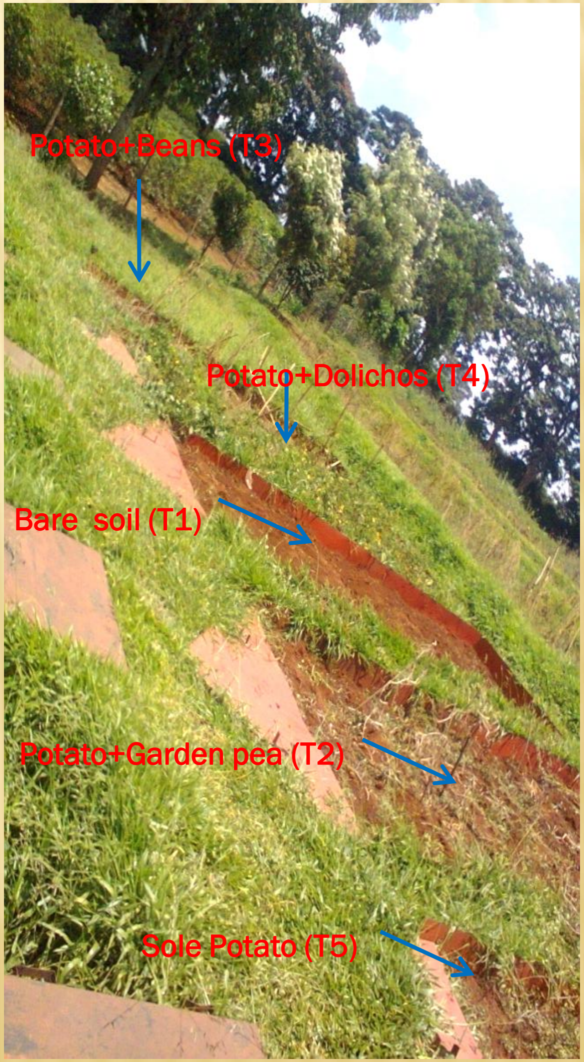
- General Linear Model analyses were performed using STATA.

RESULTS AND DISCUSSIONS

Establishment of Crop Cover



%Crop cover during the experiment period



%Cover at start of 2015 LR (20 WAP)

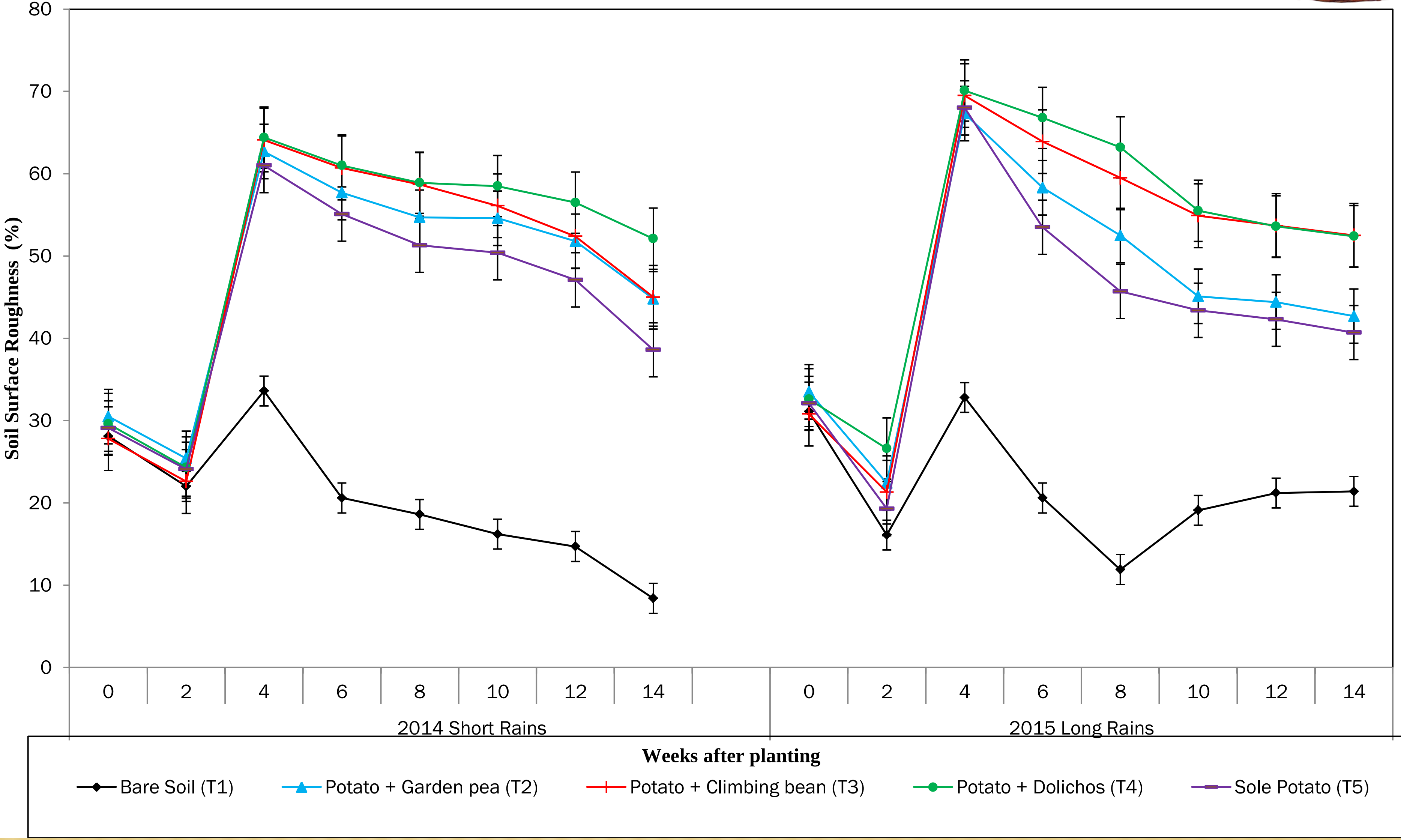
Cont'

- %Cover for Potatoes + dolichos (T4) was on average significantly higher ($P<0.05$) than that of the other treatments.

- Dolichos contributed post harvest cover greater than the critical 40% up to the start of 2015 long rains.

- This was attributed to its ability to tolerate drought conditions and to its indeterminate growth pattern.

Changes in soil surface roughness



Soil surface roughness trend during the experimental period

Cont'

- Soil surface roughness (SSR) decreased with decrease in %cover indicating that cover had influence on SSR.

- SSR soon after planting (2 WAP) indicated a sharp decline indicating that earlier rain had a greater effect on the SSR.

- SSR after every runoff event showed a significant decline attributed to scouring and smoothening of ridges by surface runoff flow.

- Potato hilling performed on 4 WAP created ridges and furrows which sharply increased SSR.

Effect of potato cropping systems on soil loss

Soil loss and runoff of potato crop compared with 3 potato /legume inter cropping system over two season

	Short Rains, 2014	Long Rains, 2015	Cumulative Soil Loss	Soil loss reduction relative to sole potato
Treatment	Soil loss (t ha^{-1})			(t ha^{-1})
Potato + Garden Pea	7.2c	20.3c	27.5c	6.4
Potato + Bean	4.9d	15.4d	20.3d	13.3
Potato+ Dolichos	2.5e	7.0e	**9.5e**	**24.4**
Sole potato	9.1b	24.8b	33.9b	-

Means followed by different letters within a column denote significant differences at 0.05 probability level.

Effect of soil surface roughness and crop cover on soil loss

Multiple linear regression analyses of soil loss under different treatments

Dependent Variable= Soil Loss				R^2=0.7280
Independent Variables	Coefficients	Standard Error	T	p>[t]
Cover	-0.252	0.067	-3.731	0.001
Surface Roughness	-0.005	0.066	-4.074	0.000
Surface Roughness x Cover	-0.268	0.001	-3.977	0.000
Treatment				
Sole potato	0.000	(base)		
Potato+ Garden Pea	-0.861	1.752	-0.491	0.626
Potato + Climbing Bean	-1.586	1.886	-0.841	0.505
Potato + Dolichos	**-1.724**	1.677	-1.028	**0.010**
Constant	13.89	2.075	6.693	0.000

Cont’

- Crop cover and soil surface roughness significantly reduced soil loss, either alone or in combination.

- Only T4 showed a significant linear dependence ($p<0.05$) of soil loss on independent variables.

- Dolichos maintained post harvest cover above 40% and minimized soil loss during off-seasons.

Enrichment ratio (ER) of eroded sediment

	pH	SOC	TN	P	K	Sand	Clay	Silt
Treatment	**Enrichment Ratio**							
Bare soil	1.03	1.16	1.25	2.01	1.15	0.89	1.18	1.15
Potato + Garden Pea	1.02	1.09	1.18	2.44	1.23	0.80	1.13	1.11
Potato + Climbing Bean	1.01	1.06	1.14	2.34	1.09	0.79	1.11	1.10
Potato + Dolichos	1.01	1.01	1.09	1.87	1.04	0.68	1.09	1.08
Sole Potato	1.02	1.13	**1.34**	**2.98**	**1.25**	0.87	1.15	1.12

Cont'

- Sole potato treatment recorded the highest ER of N, P, K due to delay in cover establishment; legumes established protective cover faster.

- ER for soil pH was above unity, indicating the eroded soil was enriched with bases relative to original soil.

- ER for sand was less than unity indicating the selectivity of the erosion process.

Soil organic matter components in eroded sediment

- Stable SOM fractions had higher concentrations of C and N indicating that much of the SOM mobilized was in stable form.

	Short Rains, 2014						Long Rains, 2015					
	Concentrations (g kg^{-1})											
Treatment	**TOC**	**POC**	**MOC**	**TN**	**PN**	**MN**	**TOC**	**POC**	**MOC**	**TN**	**PN**	**MN**
Bare Soil	28.38	9.26	19.25	2.73	0.79	1.90	28.53	9.39	19.3	2.77	0.84	1.93
Potato + Garden Pea	27.84	8.48	18.64	2.69	0.74	1.86	28.05	8.87	18.65	2.71	0.77	1.81
Potato + C. Bean	27.71	7.94	18.43	2.66	0.67	1.84	27.88	8.54	18.44	2.67	0.72	1.78
Potato + Dolichos	**27.59**	**7.72**	**18.20**	**2.63**	**0.62**	**1.76**	**27.72**	**8.28**	**18.23**	**2.64**	**0.67**	**1.67**
Sole Potato	28.09	8.78	18.75	2.70	0.76	1.88	28.12	9.03	18.77	2.73	0.8	1.89
$LSD_{0.05}$	0.117*	0.207*	0.191*	0.020*	0.019*	0.016*	0.144*	0.209*	0.195*	0.022*	0.020*	0.029*

TOC=Total Organic Carbon; POC=Particulate Organic Carbon; MOC=Mineral Organic Carbon; TN=Total Nitrogen; PN=Particulate Nitrogen; MN=Mineral-associated Nitrogen; *significant at $p<0.05$.

CONCLUSIONS

- Soil and nutrient losses in potato growing areas can be minimized by incorporating indeterminate legume cover crops such as dolichos lablab.

- Soil surface roughness induced by potato hilling can interact with crop cover to minimize soil losses due to enhanced water infiltration and rainfall interception/runoff dispersion.

- Erosion affects mainly the stable SOM fraction which forms the largest SOM reserve.

ACKNOWLEDGEMENT

CENTRO INTERNACIONAL DE LA PAPA CIP

International Potato Center (CIP)

UNITATE ET LABORE

University of Nairobi

BMZ Federal Ministry for Economic Cooperation and Development

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

THANKS FOR YOUR ATTENTION