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Prediction of Soil Erosion Under Three Tillage Systems Using RUSLE and GUEST Models

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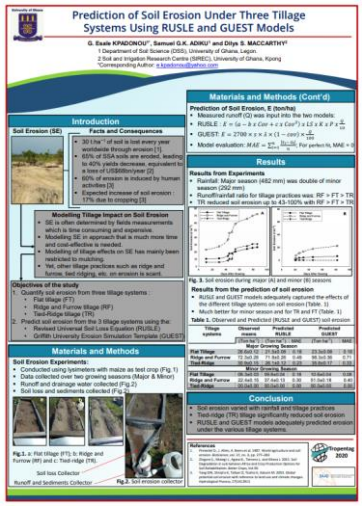

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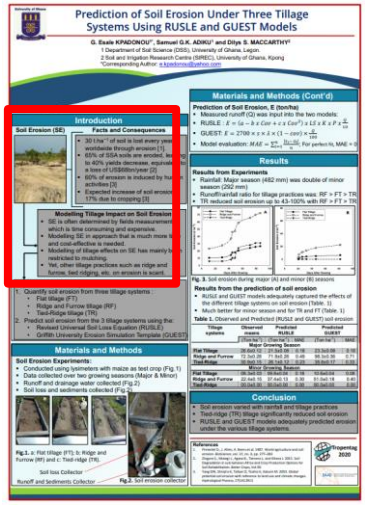

Background

- 30 t.ha^{-1} of soil is lost every year worldwide through erosion [1].
- From which 60% is induced by human activities
- Expected increase of soil erosion : 17% due to cropping [3]

Goal

- Find sustainable practices that can reduce soil erosion

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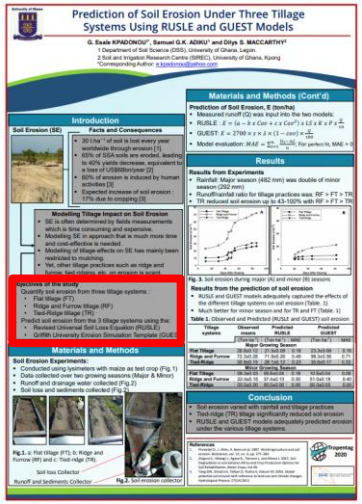
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Introduction

Soil Erosion (SE)

Facts and Consequences

- 30 t.ha^{-1} of soil is lost every year worldwide through erosion [1]
- 65% of SSA soils are eroded, leading to 40% yields decrease, equivalent to a loss of US$68/ha/year [2]
- 60% of erosion is induced by human activities [3]
- Expected increase of soil erosion : 17% due to cropping [3]

Modelling Tillage Impact on Soil Erosion

- SE is often determined by fields measurements which is time consuming and expensive.
- Modelling SE in approach that is much more time and cost-effective is needed.
- Modelling of tillage effects on SE has mainly been restricted to mulching.
- Yet, other tillage practices such as ridge and furrow, tied ridges and, on erosion is scant.

Objectives of the study

Quantify soil erosion from three tillage systems :

- Flat tillage (FT)
- Ridge and Furrow tillage (RF)
- Tied-Ridge tillage (TR)

Predict soil erosion from the 3 tillage systems using the:

- Revised Universal Soil Loss Equation (RUSLE)
- Griffith University Erosion Simulation Template (GUEST)

Materials and Methods

Soil Erosion Experiments:

- Conducted using lysimeters with maize as test crop (Fig.1)
- Data collected over two growing seasons (Major & Minor)
- Runoff and drainage water collected (Fig.2)
- Soil loss and sediments collected (Fig.3)

Fig.1. a: Flat tillage (FT); b: Ridge and Furrow (RF) and c: Tied-ridge (TR).

Soil loss Collector

Runoff and Sediments Collector

Fig.2. Soil erosion collector

Materials and Methods (Cont'd)

Prediction of Soil Erosion, E (ton/ha)

- Measured runoff (Q) was input into the two models:
- RUSLE : $E = (a - b \times Cov + c \times Cov^2) \times LS \times K \times P \times \frac{R}{90}$
- GUEST : $E = 2700 \times s \times k \times (1 - cov) \times \frac{R}{1000}$
- Model evaluation: $MAE = \frac{\sum_{i=1}^{n} |S_{Oi} - S_{Pi}|}{n}$ For perfect fit, MAE = 0

Results

Results from Experiments

- Rainfall: Major season (482 mm) was double of minor season (292 mm)
- Runoff/rainfall ratio for tillage practices was: RF > FT > TR
- TR reduced soil erosion up to 43-100% with RF > FT > TR

Fig. 3. Soil erosion during major (A) and minor (B) seasons.

Results from the prediction of soil erosion

- RUSLE and GUEST models adequately captured the effects of the different tillage systems on soil erosion (Table. 1)
- Much better for minor season and for TR and FT (Table. 1)

Table 1. Observed and Predicted (RUSLE and GUEST) soil erosion

Tillage systems	Observed means	Predicted RUSLE	Predicted GUEST
	(Ton ha^{-1})	(Ton ha^{-1})	(Ton ha^{-1})
Major Growing Season			
Flat Tillage	26.3±0.55	27.3±0.55	23.3±0.55
Ridge and Furrow	12.3±0.15	11.3±0.15	10.3±0.15
Tied-Ridge	00.0±0.00	00.0±0.00	00.0±0.00
Minor Growing Season			
Flat Tillage	7.66±0.55	8.66±0.55	9.66±0.55
Ridge and Furrow	2.0±0.15	3.0±0.15	4.0±0.15
Tied-Ridge	00.0±0.00	00.0±0.00	00.0±0.00

Conclusion

- Soil erosion varied with rainfall and tillage practices
- Tied-ridge (TR) tillage significantly reduced soil erosion
- RUSLE and GUEST models adequately predicted erosion under the various tillage systems.

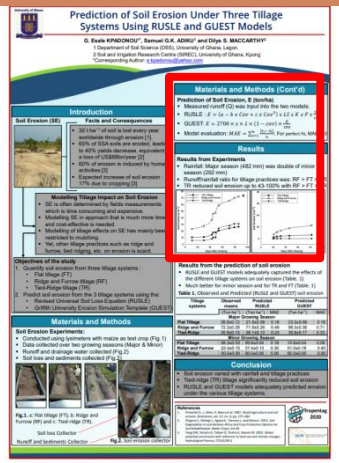
References

Prepared 2020

Objectives

1. Quantify soil erosion from three tillage systems :
   - Flat tillage (FT)
   - Ridge and Furrow tillage (RF)
   - Tied-Ridge tillage (TR)
2. Predict soil erosion from the 3 tillage systems using:
   - RUSLE
   - GUEST

Data collection

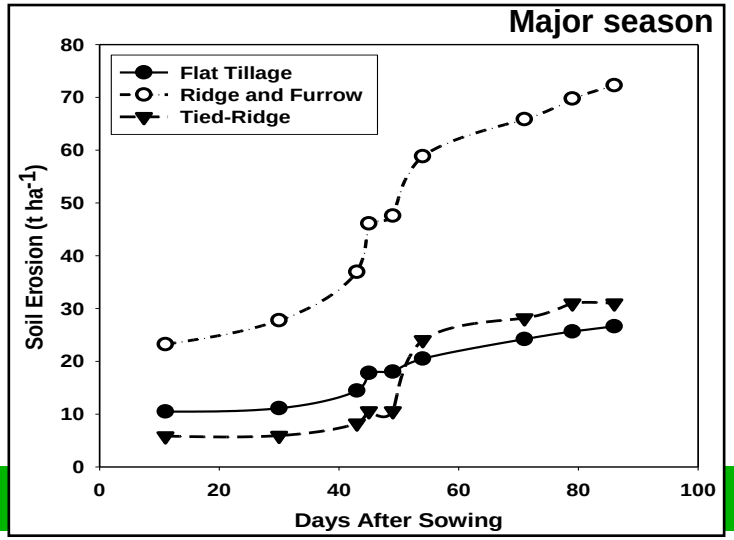


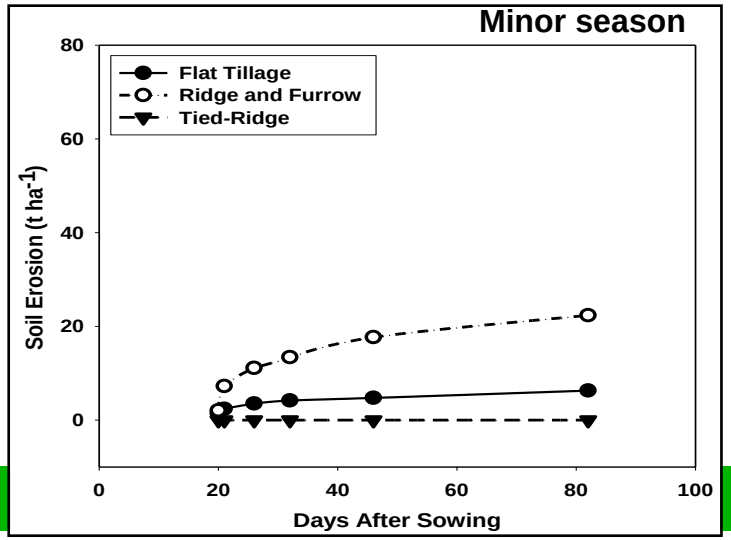
RUSLE and GUEST models

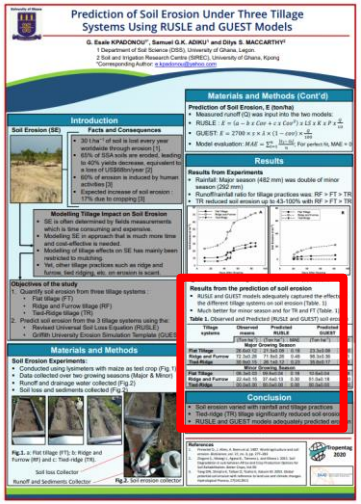
- **RUSLE :** $E = \left(a - b\,x\,Cov + c\,x\,Cov^2\right)\,x\,LS\,x\,K\,x\,P\,x\,\frac{Q}{10}$
- **GUEST:** $E = 2700 \times s \times \lambda \times (1 - cov) \times \frac{Q}{100}$
- $MAE = \sum_{i=1}^{n} \frac{|S_i - O_i|}{n}$; 0 = perfect fit

Results: Experiments

- Rainfall: Major season (482 mm) was double minor (292 mm)
- Runoff: RF > FT > TR, and TR reduced SE up to 43-100%







Results: Modeling

Major season

Tillage systems	Observed means	Predicted RUSLE		Predicted GUEST	
	(Ton ha^{-1})	(Ton ha^{-1})	MAE	(Ton ha^{-1})	MAE
Major/First Growing Season					
Flat Tillage	26.6±0.12	21.5±0.08	0.18	23.3±0.08	0.18
Ridge and Furrow	72.3±0.28	71.9±0.26	0.49	98.3±0.36	0.71
Tied-Ridge	30.9±0.15	26.1±0.12	0.23	35.6±0.17	0.33

Minor season

Tillage systems	Observed means	Predicted RUSLE		Predicted GUEST	
	(Ton ha^{-1})	(Ton ha^{-1})	MAE	(Ton ha^{-1})	MAE
Flat Tillage	06.3±0.03	09.8±0.04	0.18	10.6±0.04	0.08
Ridge and Furrow	22.4±0.15	37.4±0.13	0.30	51.0±0.18	0.40
Tied-Ridge	00.0±0.00	00.0±0.00	0.00	00.0±0.00	0.00

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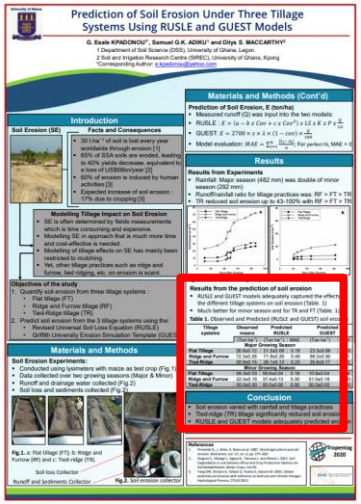

Results: Modeling

- RUSLE and GUEST adequately captured the effects of the 3 tillage on soil erosion
- Much better for minor season and for TR and FT, MAE = 0.0-0.30

Conclusion

- Soil erosion varied with rainfall and tillage practices
- TR tillage significantly reduced soil erosion
- RUSLE and GUEST can be applied for SE simulations from the 3 tillage.

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