

modelling framework

Investigating roles of sustainable intensification practices in Ghana cropping systems using crop modelling



Thuy Huu Nguyen¹, Bright Sallah Freduah², Amit Srivastava^{1, 6}, Jesse Naab⁴, Madina Diancoumba³, Dilys Sefakor MacCarthy², Kwasi Godfried Samuel Adiku⁵, Heidi Webber³, Thomas Gaiser¹

¹ Crop Science Group, Institute for crop science and resource conservation (INRES), University of Bonn, Germany; ² Soil and Irrigation Research Centre, School of Agriculture, University of Ghana, Ghana; ³ Integrated Crop System Analysis and Modeling, Leibniz Center for Agricultural Landscape Research (ZALF), Germany; ⁴ Savana Agricultural Research Institute, Wa, Ghana; ⁵ Department of Soil Science, School of Agriculture, University of Ghana, Ghana; ⁶ Multi-Scale Modelling and Forecasting, Leibniz Center for Agricultural Landscape Research (ZALF), Germany



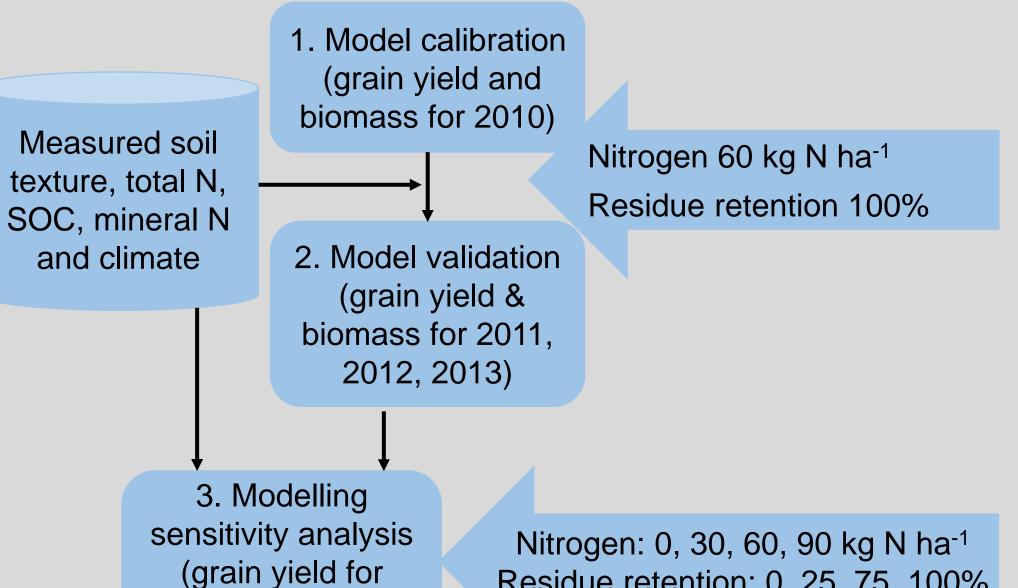
INTRODUCTION

- Highly spatial and temporal heterogeneity of soil, seasonal climatic characteristics, and . local inputs
- Upscaling of sustainable intensification (SI) practices from specific locations to regional scales
- Comprehensive field trials which are often lacking in Africa
- Dynamic crop modeling systems incorporating

MATERIALS AND METHODS

- **Experimental data:**
- Locations: Northern Ghana
- Field trial data: Naab et al., (2017)
- Cropping system: sole maize
- Growing season: 2010, 2011, 2012, 2013
- Soil types: Ferric soil
- Crop models:
- SIMPLACE <LINTUL5> and APSIM
- Crop practices scenarios: crop residue retention

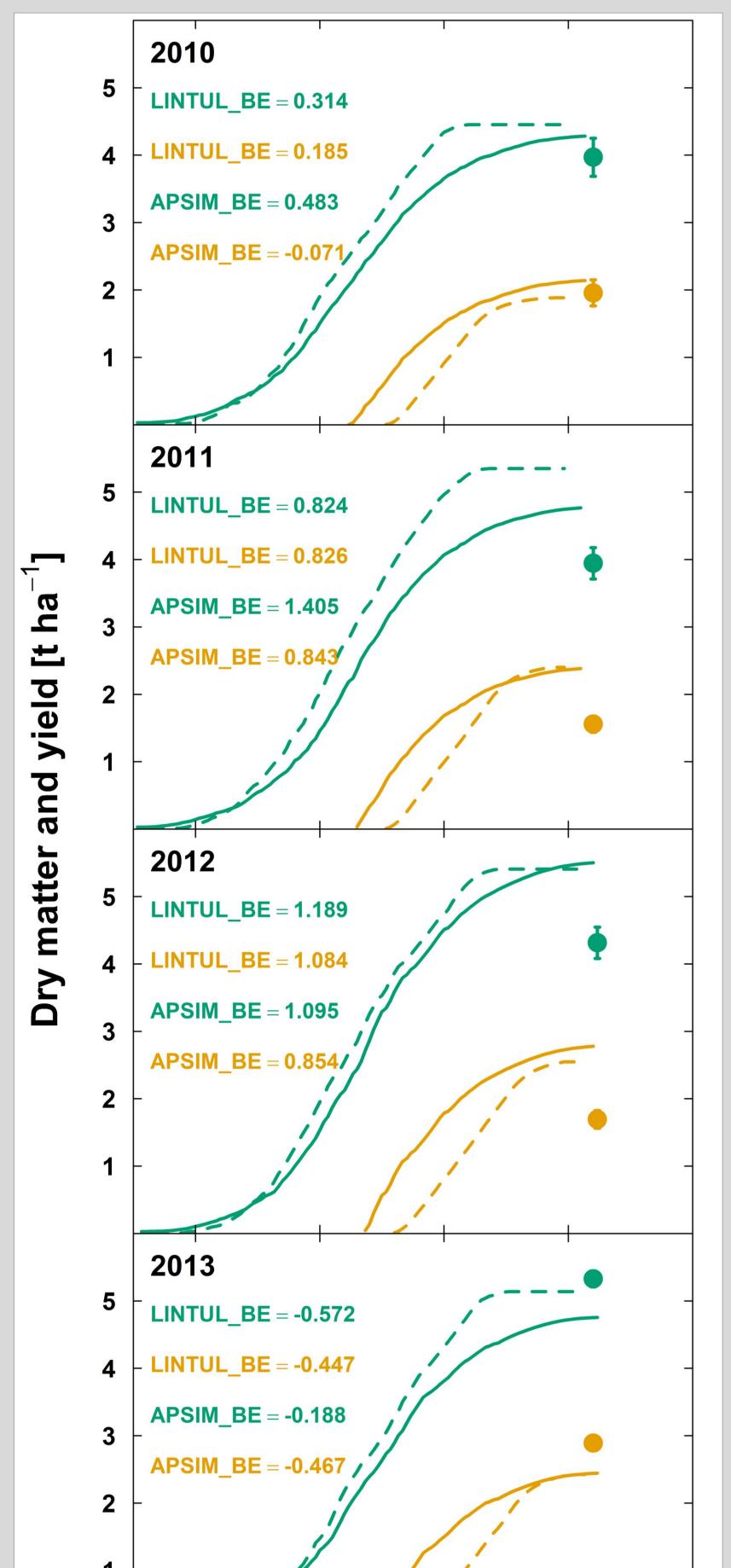
Modelling workflow



SI practices [e.g. crop residue retention (R) or varied nitrogen (N) is used to investigate the effects of those SI practices on crop yield and soil nutrients

RESULTS

- **1. Modeling calibration**
- Bias errors of yield were at 0.314 and 0.328 ton ha⁻¹ for LINTUL5 and APSIM, respectively.



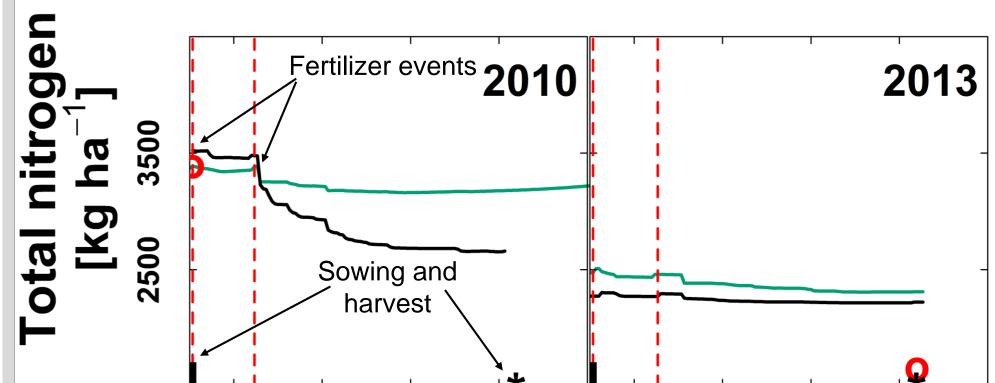
(R): 0, 25%, 75%, and 100% & chemical N: 0, 30, 60, and 90 kg N ha⁻¹

HIGHLIGHTS

- Comparison to N60-R100, adding Or reducing 30 kg N ha⁻¹ or reducing residue to soil do not have strong effects on grain yield for the selected trial.
- Modeling differences and uncertainty are high when lack of observed data.

RESULTS

2. Modelling validation (continued)



2010, 2011, 2012, 2013)

Residue retention: 0, 25, 75, 100%

4 years x 4 N levels x 4 Residue retention = 64 simulations

RESULTS

Average RYC compated to N60-R100 (considred as current SI practices in farmer fields) of different residue retention scenarios in 2012

Model	Scenario N (kg ha-1)	RYC (%)
APSIM	NO	-98
	N30	-17
	N60	-8
	N90	6
LINTUL5	NO	-31
	N30	-14
	N60	-6
	N90	8

Comparing N60-R100 with N0-R0, yield was

reduced by average of 31% (LINTUL5) and

					_
	08/30	10/30	08/30	10/30	
Date [mm/dd]					

Depletion of total N after 04 seasons was high. Two models overestimated total N in 2013.

3. Modelling sensitivity analysis

60 ·

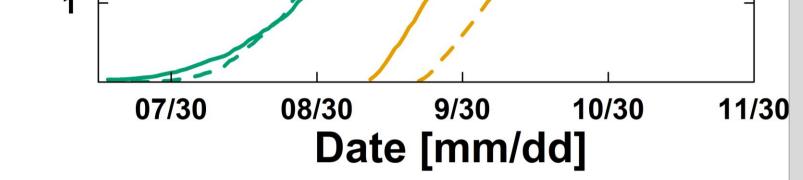
to N0-R0 [%]

compared

Relative yield change

almost 98% (APSIM). Compared to N60-R100, RYC was not much when increase/decrease of 30 kg N ha⁻¹. 2011 2012 2013 2010 Nitrogen scenarios N30 N60 N90 R100 R75 R100 R100 R75 R75 R0 R25 R0 R25

Residue scenarios



2. Modelling validation

- Two models overestimated biomass and yield in 2011 and 2012, with bias errors around 0.9 ton ha⁻¹, while underestimating grain yield by around 0.5 ton ha^{-1} in 2013.
- change (RYC) yield Relative due to chemical N input was larger than due to residue retention.
 - RYC simulated by APSIM was higher (10-20%) than simulated RYC by LINTUL5.
 - Adding chemical N input (90 kg) increased 30-60% grain yield compared to N0-R0.

Difference of APSIM and LINTUL5 models was due to differrence in initial set-up for N60-R100.

OUTLOOK

Needs to add more sensitivity analysis with different soil types, P fertilizer levels, cropping systems (maize-soybean rotation, intercropping etc...)

References:

Naab et al., (2017); Ender et al., (2023) Probert et al., (1997); Thorburn et al., (2010)



Sponsors:

Bundesministerium für Bildung und Forschung

Contact: Thuy Huu Nguyen/ tngu@uni-bonn.de