Towards a Cropping System Sustainability Tool (CROSST) –Evaluating Performance of Green Manure Cover Crops in Benin and Kenya: A Pilot Study

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Introduction

Soil degradation poses a serious threat to food production and rural livelihoods in sub-Saharan Africa[1]. Nutrient mining ,as a result of unsustainable farming practices, have left the soils unfertile (Fig.1). Green Manure Cover Crops (GMCC's) are a promising intervention to improve soil health [2].Benefits from GMCC's are well known; however, there has been low uptake. Information on how GMCC technologies impact on profits, soil health ,and ecosystem services had not been thoroughly assessed[3]. Therefore, a **Cropping System Sustainability Tool** (CROSST) was developed to better understand agro-environmental and socio-economic impacts and trade-offs of GMCC integration in cropping systems.

The tool was pilot tested in Benin and Kenya under the German Federal Ministry for Economic Cooperation and Development (BMZ)/Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) program on 'Soil Protection and Rehabilitation for Food Security.'

Fig. 1. Unsustainable farming practices, burning of crop residues top photo, promoted GMCC practices maize intercropped with GMCC pigeon pea in the bottom photo.

CROSST Approach

CROSST adopted principles from the static rule-based framework[3]:

(i) Generating crop rotations and indicators of interest (using experts' knowledge, Fig. 2)

(ii) Selecting agronomic, environmental, and socio-economic parameters

(iii) Assessing and comparing cropping systems with and without GMCCs

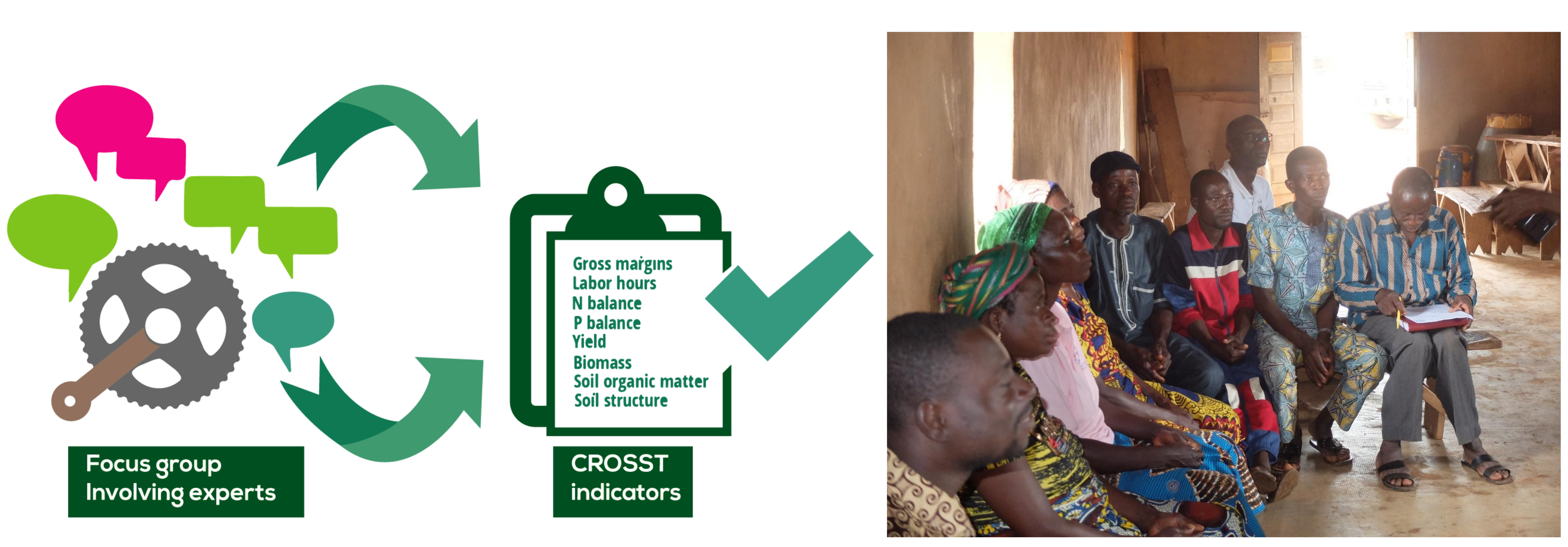


Fig.2. Basic steps of CROSST using expert knowledge and defining key indicators (left), focus group discussions with farmers during data collection for model parametrization (right).

CROSST captures the aggregated annual effects of specific cropping systems over three years (or six seasons). The model is composed of an input sheet, an output sheet, and nine parameter and calculation sheets (Fig.3). The output of the tool consists of bar graphs, trade-off graphs, and relative scores, e.g. (Fig.4&5)

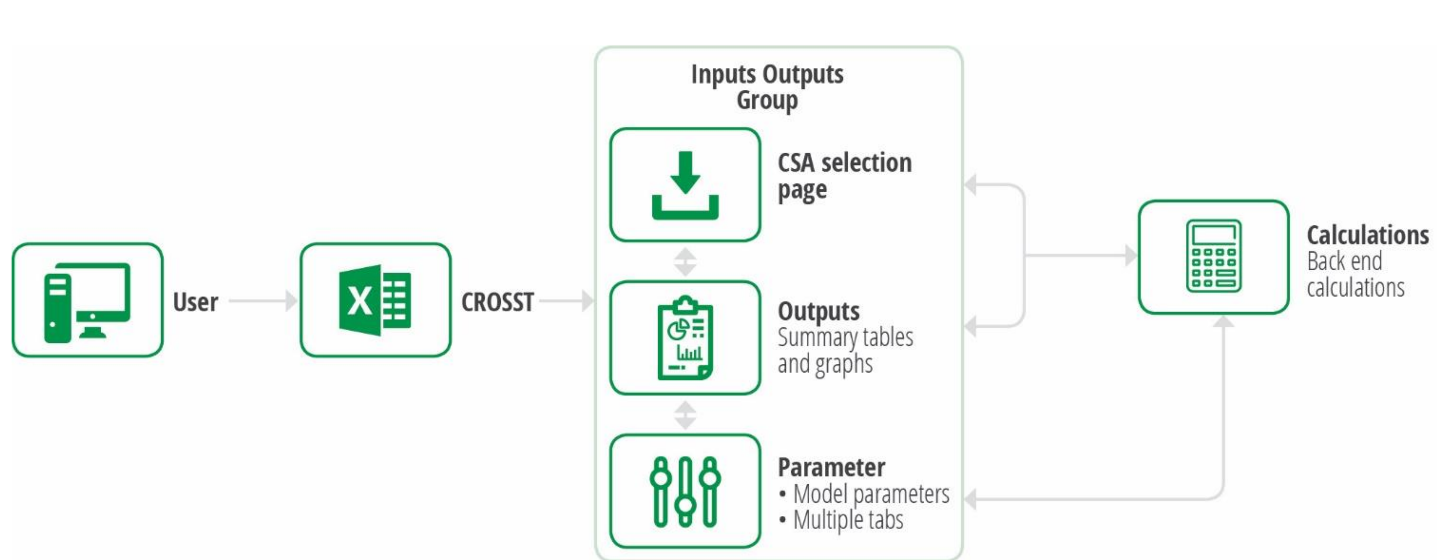
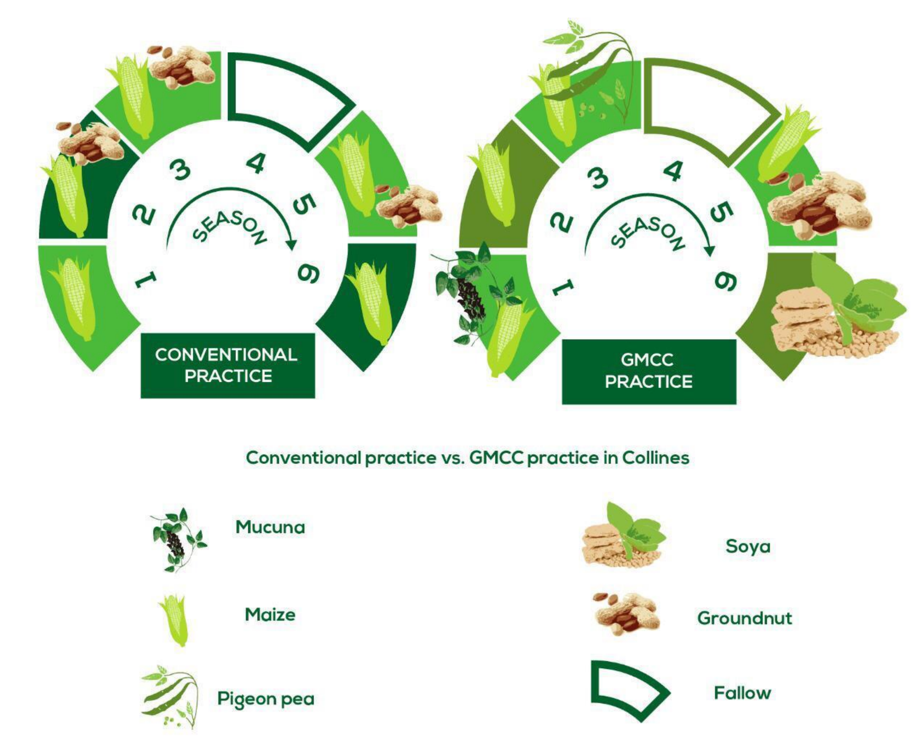


Fig.3. Overview of CROSST model

Cropping Systems Assessment

For each country and zones defined, one conventional system was compared to one improved system (with integrated GMCC) to illustrate the functionality of the tool (Fig.4).



			Season 1	Season 2	Season 3	Season 4	Season 5	Season 6	Sum	Average/ha/Season
Cropping System Conventional			Maize	Maize/Groundnut	Maize/Groundnut	Fallow	Maize/Groundnut	Maize		
SFerrugineux	Gross Margin	USD/ha	129	1216	1166	0	1164	163	3838	639.7
	Labor hours	h/ha	266	374	374	0	322	266	1602	267.0
	N Balance	kgN/ha	1	-40	-37	5	-37	-3	-110	-18.3
	P Balance	kgP/ha	7	-7	-7	0	-7	6	-7	-1.2
	Yield1	kgDM/ha	1111	1857	1774	0	1772	1306	7820	1303.4
	Yield2	kgDM/ha	0	1557	1498	0	1497	0	4552	758.7
	Biomass1	kgDM/ha	1025	1714	1638	0	1636	1206	7219	1203.1
	Biomass2	kgDM/ha	0	3466	3335	0	3332	0	10133	1688.8
	SOM/Soil Structure									

			Season 1	Season 2	Season 3	Season 4	Season 5	Season 6	Sum	Average/ha/Season
Cropping System GMCC			Maize/Mucuna	Maize	Maize/Pigeon Pea	Fallow	Maize/Groundnut	Soya		
SFerrugineux	Gross Margin	USD/ha	892	122	1058	0	891	593	3555	592.4
	Labor hours	h/ha	364	258	364	0	312	330	1628	271.3
	N Balance	kgN/ha	-19	-5	89	5	57	41	169	28.2
	P Balance	kgP/ha	-7	-2	-17	0	-12	-11	-49	-8.2
	Yield1	kgDM/ha	1439	694	1631	0	1342	1126	6232	1038.7
	Yield2	kgDM/ha	729	0	1256	0	1067	0	3052	508.7
	Biomass1	kgDM/ha	1328	641	1505	0	1239	1555	6268	1044.7
	Biomass2	kgDM/ha	230	0	4206	0	2375	0	6811	1135.2
	SOM/Soil Structure									

Fig.4. Comparison of conventional versus GMCC cropping systems in one agro-ecological zone in the south of Benin over a period of six seasons (top center infographic). Centre image and bottom image are the output tables from CROSST quantifying impacts of the conventional and GMCC cropping systems.

In the three zones in Benin incorporating GMCC's improved N balances but came at the expense of profits except for Borgou (Fig.5).

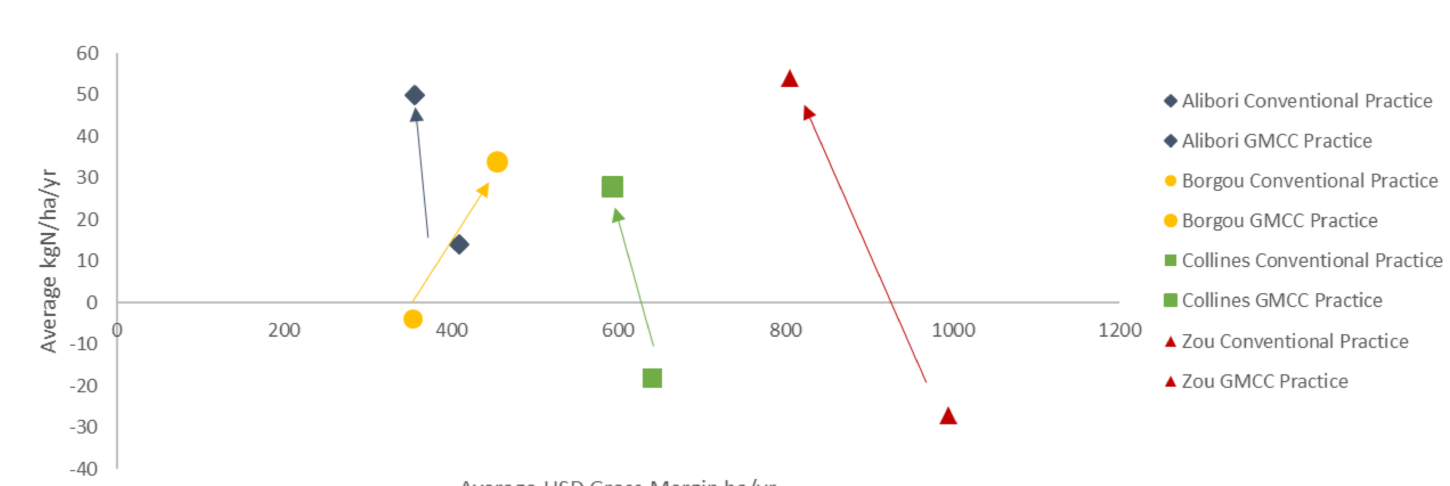


Fig.5. Trade off of gross margin *versus* N balance in four study zones of Benin.

Conclusions

- CROSST was successful in quantifying the effects of cropping systems with and without GMCCs.
- GMCC technologies improve soil structure/soil organic matter as well as soil N balances in the two regions assessed.
- Farmers prefer dual-purpose GMCCs as they strike a balance between food security, income, and soil improvement.
- Farmers often strive to satisfy several objectives instead of maximizing on one.
- CROSST still requires further refinement such as using agriculture census data and validating results.
- CROSST can serve as a decision-support tool for development agencies, implementing partners, and local stakeholders when designing sustainable cropping system.

For More Information

Link to **Tool** / https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/86009C

Link to **Working paper** / https://cgspace.cgiar.org/handle/10568/102440

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